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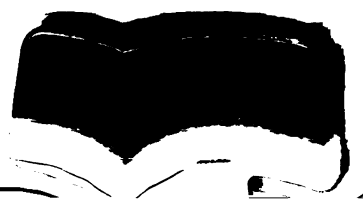

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Trans.

Compliments of the U. S. Deep Waterways Commission.

James B. Angell,
John E. Russell,
Lyman E. Cooley.

Per ..... Chicago, October, 1897.

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REPORT

OF THE

UNITED STATES DEEP WATERWAYS COMMISSION,

PREPARED

AT DETROIT, MICHIGAN, DECEMBER 18–22, 1896,

BY THE COMMISSIONERS,

JAMES B. ANGELL, JOHN E. RUSSELL, LYMAN E. COOLEY.

ACCOMPANIED BY THE REPORT ON TECHNICAL WORK AND THE SEVERAL TOPICAL REPORTS AND DRAWINGS PERTAINING THERETO.

JANUARY 18, 1897.—Referred to the Committee on Interstate and Foreign Commerce, with accompanying papers, and ordered to be printed.

WASHINGTON:
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1897.

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LETTER OF TRANSMITTAL.

To the Senate and House of Representatives:

I transmit herewith the report of Messrs. James B. Angell, of Michigan, John E. Russell, of Massachusetts, and Lyman E. Cooley, of Illinois, who were appointed Commissioners under the authority of a law passed March 2, 1895, to make inquiry and report, after conference with such similar commissioners as might be appointed on behalf of Great Britain or the Dominion of Canada, concerning the feasibility of the construction of such canals as will enable vessels engaged in ocean commerce to pass between the Great Lakes and the Atlantic Ocean, and the most convenient location and probable cost of such canals, together with other facts and information in said act specified relating to their construction and use.

The Commissioners have prosecuted the work assigned them with great zeal and intelligence, resulting in the collection of a mass of information, embodied in their report and its accompanying exhibits, which is of great importance and interest as related to the project subjected to their examination.

The advantages of direct and unbroken water transportation of the products of our Western States and Territories from convenient points of shipment to our seaboard ports are plainly palpable. The report of the Commissioners contains, in my opinion, demonstration of the feasibility of securing such transportation, and gives ground for the anticipation that better and more uninterrupted commerce through the plan suggested, between the great West and foreign ports, with the increase of national prosperity which must follow in its train, will not long escape American enterprise and activity.

It will be observed that the report of the Commissioners, though as comprehensive as the time and facilities at their disposal permitted, does not definitely deal with the cost of the work they were called upon to consider, and omits some of the other details related to it. Thus far they have labored without compensation, and a part of the small sum appropriated for the payment of their expenses still remains unexpended.

I suggest to the Congress the propriety of making economical provision for such further prosecution of their work as will more fully develop the information necessary to an exact and complete understanding of this interesting and important subject.

GROVER CLEVELAND.

EXECUTIVE MANSION,
January 18, 1897.

WASHINGTON, *January 8, 1897.*

The PRESIDENT:

By instruction of the Deep Waterways Commission, I herewith transmit its report made in pursuance of the joint resolution of Congress which became a law March 2, 1895, under which the Commission was appointed November 4 following.

Respectfully, yours,

JOHN E. RUSSELL,
Member of the Commission, and its Secretary.

REPORT OF THE UNITED STATES DEEP WATERWAYS COMMISSION.

On the 8th day of February, 1895, Senator William F. Vilas introduced the following joint resolution, authorizing a preliminary inquiry concerning deep waterways between the ocean and the Great Lakes, and providing commissioners therefor:

Resolved by the Senate and House of Representatives of the United States of America in Congress assembled, That the President of the United States is authorized to appoint immediately after the passage of this joint resolution three persons, who shall have power to meet and confer with any similar committee which may be appointed by the Government of Great Britain or the Dominion of Canada, and who shall make inquiry and report whether it is feasible to build such canals as shall enable vessels engaged in ocean commerce to pass to and fro between the Great Lakes and the Atlantic Ocean, with an adequate and controllable supply of water for continual use, where such canals can be most conveniently located, and the probable cost of the same, with estimates in detail; and if any part of the same should be built in the territory of Canada, what regulations or treaty arrangements will be necessary between the United States and Great Britain to preserve the free use of such canals to the people of this country at all times; and all necessary facts and considerations relating to the construction and use of deep-water channels between the Great Lakes and the Atlantic Ocean.

The persons so appointed shall serve without compensation in any form, but they shall be paid their actual traveling and other necessary expenses, not exceeding in all ten thousand dollars, for which purpose the said sum of ten thousand dollars, or so much thereof as may be necessary, is hereby appropriated. The President may, in his discretion, detail as one of such persons an officer of the United States Navy or of the Army.

This resolution having passed the Senate (S. Res. 130) was favorably reported to the House by Mr. Wise from the Committee on Interstate and Foreign Commerce, and was incorporated in the sundry civil appropriation bill and became a law on March 2, 1895 (U. S. Pub. Doc. 122, p. 44). On November 4 the President announced appointments, under the law, of Commissioners: James B. Angell, of Ann Arbor, Mich.; John E. Russell, of Leicester, Mass.; Lyman E. Cooley, C. E., of Chicago, Ill.

Soon after the Government of the Dominion of Canada appointed Commmissioners: Oliver A. Howland, M. P. P., of Toronto; Thomas C. Keefer, C. E., of Ottawa; Thomas Monro, C. E., of Coteau Landing.

The United States Commission met at Detroit January 13, 1896, and organized with Mr. Angell as chairman and Mr. Russell as secretary. The time and place of meeting were chosen on account of the annual meeting of the Lake Carriers' Association. A week was spent in taking the testimony of ship owners, masters, and merchants, who were present at this meeting.

On the 18th of January a joint meeting was held with the Commissioners of the Dominion of Canada. The United States Commission made a plan of the work necessary to accomplish, so far as its means would allow, the purpose of the law. The exhibits of detailed reports,

drawings, maps, and the report upon the technical work of examination will show what has been done. The material discovered in all quarters where search has been made has proved to be of far more importance than was conjectured, and the Commission has been directly led to make recommendations for the action of Congress.

The Canadian Commission has furnished all the matter, much of it of great importance, contained in the public offices of the Dominion, cordially responded to all inquiries, and made special surveys on the route from Lake St. Francis to Lake Champlain by the Richelieu River, the results of which have been laid before our Commission. Examination of the statistics of lake traffic, increasing with a rapidity but little understood, except by those occupied in it, must lead the statesman to consider what assistance Government can give to promote an internal commerce of such direct benefit to the whole country.

The most profound economic changes of modern times have been brought about by the improvements in transportation. These began with small canals and later with railroad construction, in the first half of the century, and have proceeded with accelerating speed to the present time.

The railroad of to-day bears about the same relation to the transportation of thirty years ago as that did to the stage coach and freight wagon of the first quarter of the century. The general use of steel has given an efficiency and security to railway traffic far surpassing even the prophesies of enthusiasts. This has been accompanied by the utilization of steel in shipbuilding, which may be said to date from 1878, as in that year less than 2 per cent of steel was used in construction of ships in Great Britain. Minor inventions in the improvement of marine engines and locomotives have accompanied the greater changes, and resulted in affecting the living and exchanges of the whole world, and greatly broadening the line of separation between progressive and unprogressive peoples.

In the first half of the century each nation practically depended upon its own agriculture for the subsistence of its people. States or communities isolated by distance or mountain ranges might suffer from famine. A bushel of wheat raised far west of the shore of Lake Superior and now consumed by cotton spinners in Lancashire, 5,000 miles away from the field of its growth, might have its value exhausted by a wagon haul of a hundred miles.

Now the combined stock of the world is the daily visible supply; its amount is known in every city and its accessibility is fully understood.

In 1869 occurred the opening of the Suez Canal, which brought the East into competition with Western civilization by reducing a voyage of six or eight months to thirty days, virtually destroying the value of the fleet of sailing vessels previously employed, and making it necessary to readjust ancient systems of distribution and all the capital and labor incidental to them.

A part of the effect of this rearrangement of the world's commerce upon the business of this country may be seen in the reductions of the freights upon grain about 75 per cent, and enabling India to enter the markets of Europe with wheat to the amount of 34,000,000 bushels annually from 1881 to 1885. The magnitude of commercial change or disturbance in reduction of values may be estimated from the fact that in 1869 the value of the total trade of India with foreign countries was $527,000,000. Five years later it had fallen off $50,000,000 in value, but had so increased in volume as to employ an increase of 250,000 tons of steam shipping, an equivalent of 500,000 tons of sail.

The future of this commerce between the western world and eastern nations, increased by the introduction of better methods of production and stimulated ambition, must be left to conjecture.

The agricultural competition we have been compelled to meet from India has lately been intensified by the entrance into the world's market of the rising States of the south of our continent. These circumstances, which will change only in the direction in which they are moving, strongly appeal to us to examine in what manner we can lighten the burdens of our agriculture and keep pace with the world's progress by facilitating and cheapening our internal transportation.

The limit of reduction in railroad freights seems to have been reached; it remains to be determined if it is not possible to extend lake navigation to the ocean by a practicable ship channel, for although the development of our natural waterways is but little advanced beyond the bounty of nature, and is capable of immediate and vast extension, the effect of the little we have done has been enormously profitable.

The chain of great lakes, with a water surface of 95,965 square miles, a basin area of 312,365 square miles, and coast lines in the United States limits of 3,075 miles, gives us a deep, fresh-water navigation, the extent of which can not be accurately stated, so rapidly does it increase.

If it is overestimated in enthusiastic estimate, the calm statistics soon overtake the exaggeration.

The coast lines of the lakes border upon nine States, containing more than one-third of our population, and upon their harbors are six cities, with an aggregate population of 3,000,000, and hundreds of rapidly growing towns. The increased power of navigation effected by the Welland canal, through which vessels of a cargo capacity of 1,700 tons are passed into Lake Ontario and thence to Ogdensburg, a distance from Duluth of 1,235 miles, the enlarging and deepening of harbors and the connecting channels of the lakes, and the building of powerful rapidly working locks at the Falls of St. Mary, have given such commercial results that any suggestion of improvement upon a wider scale must at once secure favorable notice.

The amount expended by the United States upon lake navigation, in widening and deepening channels, is about $12,000,000, and marine history contains no parallel to the rapid development which has been made possible by this assistance. The largest item in the lake traffic, the transportation of iron ore from the Superior shores, has been made possible by the locks at St. Marys Falls and the deepening of the connecting channels. The importance of this industry, but yet in its infancy, can not be estimated.

The richest iron ores are now delivered along a line of coast of 1,000 miles, dotted with manufacturing towns. This has cheapened iron and steel below the cost in any other part of the world. The development of this industry has worked a revolution scarcely less important than the enlargement of harbors, channels, and locks, in the shipbuilding of the lakes.

As steam took the place of sail, so iron and steel have succeeded wood, and there is no part of the seaboard where vessels can be so cheaply built as in the shipyards of the lakes. These enterprising builders are confined to their own shores. Were they not landlocked in their fresh-water seas, they might compete with the shipbuilders of the world.

The increase of tonnage and freights can be better understood from a table showing the business of the locks at St. Marys Falls during ten years:

Year.	No. of vessels.	Tonnage.	Net tons freight.	Year.	No. of vessels.	Tonnage.	Net tons freight.
1885	5,380	3,035,937	3,256,628	1891	10,191	8,400,685	8,888,759
1886	7,424	4,219,397	4,527,759	1892	12,580	10,647,203	11,214,[illegible]33
1887	9,355	4,897,598	5,494,649	1893	12,008	8,949,754	10,796,572
1888	7,803	5,130,659	6,411,423	1894	14,491	13,110,366	13,196,860
1889	9,579	7,221,935	7,516,022	1895	17,956	16,806,781	15,062,580
1890	10,557	8,454,435	9,041,213	1896	18,615	17,249,418	16,239,061

The estimated value of freight in 1895 was $159,575,130.

In 1894 the St. Marys Falls Canal was open for 234 days, about 10 days more than the average time The Suez Canal, which is open all the year, passed 3,352 ships, with a tonnage of 8,039,105, or 5,071,261 less net tonnage than the canal connecting the lower lakes with Lake Superior.

The amount of freight passed by this canal in two hundred and thirty-four days was equal to 13.6 per cent of all the freight carried by all the railroads of the United States for the entire year.

In 1889 the late Mr. George H. Ely published an estimate of the traffic passing through the Detroit River. He made it three times greater than the foreign trade of the port of New York. It exceeded the aggregate foreign trade of all the seaports of the United States by 10,000,000 tons, and was 3,000 tons more than the foreign and coastwise trade of London and Liverpool combined. At the annual meeting of the Lake Carriers' Association, at Detroit, January, 1896, the statement was made that in 1895 the ton mileage of vessels passing Detroit was estimated at 22,395,251,250. The cost per ton per mile was 0.85 of a mill. The net tons of freight carried was stated to be 29,860,335.

The effect of this enormous trade upon the increase of manufacturing may be partly estimated by the growth of Cleveland. The city, at the mouth of the Cuyahoga River, near the lower end of the deep water from Duluth to Buffalo, had a population of about 80,000 in 1876. It was not expected that there would be any especial development of business there, but the deepening of the connecting channels of the lakes has created a trade in ore and coal which has carried the population of Cleveland to 350,000 people, and its shipyards rival the busiest in the world in their activity.

The increase of the business of Buffalo in receiving, storing, and forwarding grain and lumber, in shipbuilding, and in general manufacturing is a matter of common knowledge.

This may be called the eastern terminus of deep-water navigation and receives a large proportion of the grain bound to the seaboard. For export and distribution, Duluth, Superior, Chicago, Milwaukee, and Toledo all send the greater part of their grain and flour to Buffalo. The table of receipts of grain at Buffalo nearly equals the total exports of grain from all ports of the United States. For three years past the receipts were, reckoning flour in bushels—

1893	187,235,160
1894	160,968,095
1895	162,988,842

At Buffalo bulk has to be broken, the grain elevated and transferred to cars or canal boats, and the same thing, with equal expenses, is repeated at New York.

The lake freight from the farthest shore of Lake Superior and of Lake Michigan to Buffalo is from 1 to 1½ cents a bushel. The ocean freight averages about 3 cents, making 4 to 4½ cents for the deep-water carriage of 4,000 miles. The whole cost from Chicago or Duluth to Europe is from 9 to 10 cents for a bushel of wheat. Therefore more than half the cost is in elevator charges, commissions, and canal freights, to which must be added the item of waste.

It costs twice as much to carry a barrel of flour from Duluth to New York as it does from New York to Europe, though the latter distance is more than twice as great as the former.

If an ocean steamer could clear from an upper lake port to Europe, it would save the time and expense required to break bulk at two intermediate points, and the cost of carriage would be about one-half of what it is now. Such a vessel could carry her cargo from the east end of Lake Erie to the ocean for not exceeding 1 cent a bushel for the additional water distance.

In 1885 the United States was the principal source of wheat supply to make up the deficiency in the world's markets, notwithstanding that the opening of the Suez Canal in 1869 had brought India into competition with us, and the British East Indian Government had by railways, canals, and irrigation greatly stimulated the growth of wheat. From 1881 to 1885 the average export from the United States in grain and flour was 122,157,043 bushels. In the same time the average supply from our competitors was—

Canada	2,906,218
Argentina	2,015,118
Uruguay	77,296
Russia	76,189,773
India	34,580,707

Five years later changes of a most ominous character had taken place. The world's supply had greatly increased, prices were on a much lower level, and the competition was from an unexpected quarter.

From 1891 to 1895 the exporting countries poured into the markets as follows:

United States (wheat and flour in bushels)	171,731,480
Canada	10,196,601
Argentina	34,617,381
Uruguay	1,619,489
Russia	105,581,617
India	29,251,323

This shows a yearly average increase from 1891 to 1895 of 114,000,000 bushels over the years from 1881 to 1885. The percentage of increase is nearly divided between the United States and Russia. India falls off. Canada trebles her surplus production, and from the southern part of the continent new and threatening competition rapidly enters the market.

This new feature appears all the more dangerous if we examine the production of these later years. 1891 was an unusual and uneven wheat year. There was a partial failure of crop in Europe. The Russian crop was exceedingly light with agricultural distress; the crop of the United States was the best ever known with active demand and firm prices. In this year the Argentinian crop was 36,000,000 bushels

and the Uruguay crop 3,000,000; but in 1895 the Argentinian crop rose to 75,000,000 and the Uruguay crop to 10,000,000 bushels, of which 6,000,000 of bushels in grain and flour were available for export.

While the crop reports of the present year indicate that our southern competitors are subjected, like ourselves, to variable and even disastrous seasons, their standing in the market is established and their production of wheat and corn will undoubtedly greatly increase. When they have bountiful harvests, we must meet very low prices. The Empire of Russia is making prodigious advances in connecting her distant grain fields with the coast and her competition will undoubtedly increase rather than diminish.

A few years ago agricultural products and lumber made the cargoes of lake shipping, but a new industry has arisen from the recent discoveries of iron ore in the Lake Superior region, which, under favorable conditions of transportation, bids fair to bring about far-reaching, economic changes.

Three-quarters of the iron ore brought into use from these discoveries has been produced during the last ten years, and the amount of capital interested in mining and transportation is now estimated at $234,000,000. The proportion of this recent business to the iron industry of the country may be seen in the statistics of 1892. In that year there was put out 16,036,043 tons of ore, of which the Superior region gave 9,564,388 tons. But when it is taken into account that these ores surpass in richness the ores of any other part of the country, the proportion of value is much greater than appears by weight. New discoveries are constantly reported, and the ease of access to the deposits makes it possible to supply any possible demand. The rapidity of the development of this industry in its infancy seems to establish that, with access to the ocean by a practicable waterway, we can not only control our own iron and steel trade, but can enter into competition in any market. Some of our large iron and steel plants are upon the seacoast and are importers of foreign ores, as the low value of iron ore in proportion to its weight will not permit them to pay railway freights on the ores of the Superior region. The position of these coast iron works is similar to that of the same industry in Great Britain and Germany. The ores of those countries are not suitable for Bessemer steel, and for some years past their furnaces have been supplied from the mines in the north of Spain, which are the only accessible ores in Europe, so far known, that compare in purity and richness with those of our lake region.

Now the iron masters of Europe are confronted with the discovery that the Spanish deposits are rapidly being exhausted; they will this year supply 6,000,000 tons, four-fifths of which goes to England. At this rate, and with the prices of ore rising as the quantity diminishes, ten years will exhaust the mines of the Biscay region. The other mines of Spain are on the Mediterranean and are small deposits, about 100 miles from the coast.

Another possible resource is in the mines of central and northern Sweden. These are ores of great purity, but low in iron and with a long haul by rail, so that they can not be cheaply afforded.

This condition of European manufacturing indicates that soon our iron masters can sell their iron and steel in all forms in any part of the world. With deep-water access to the ocean, the ores required on the Atlantic could be supplied to the exclusion of foreign ores, the iron and steel business of the country equalized, and our country supplied at a minimum of cost, enlarging the field for capital and industry and

increasing the prosperity of the whole. At the same time, furnaces and rolling mills on the lakes could produce iron and steel that, water borne, would irresistibly invade the markets of the world.

The foregoing remarks upon the present commerce of the lakes are capable of wide extension.

We append hereto as a part of this report the report of Mr. Cooley upon the technical work which has been carried on under his immediate supervision, accompanied by certain detailed reports and drawings, which are set forth in three exhibits.

Exhibit A consists of profiles and maps of water routes with explanatory texts, comprising profiles Nos. 1 to 14 inclusive, two maps, a general report, and two special reports. This exhibit comprehends the several routes which have been considered and advocated by diverse interests, and practically covers the available information. In compiling them recourse has been had to all sources of information, as surveys and examinations made by the two Governments, by State and provincial authority, by corporations, and by individuals. It was found necessary to make special examinations in the field of the Mohawk route and of that portion of the St. Lawrence-Champlain route between Lake Ontario and Lake Champlain, and these are covered by special reports. No attempt has been made to define projects, the presentation being limited to the characteristic physical features upon a uniform scale for purposes of comparison.

Exhibit B consists of five special topics, illustrated by one map and seven diagrams, designed to develop the considerations affecting riparian interests of unprecedented magnitude, and the conditions limiting the capacity and character of works. The first topic reviews the data pertaining to elevations and data planes, to which all records and plans are referred. The second sets forth the fluctuations of the several lakes and the St. Lawrence River from 1860 to October, 1896, inclusive, and is accompanied by complete tables and by diagrams showing graphically the record and the important deductions. A discussion of these data determines a certain common plane, or standard low water, throughout the bodies of water under consideration, to which all profiles and water levels have been reduced. The necessity of some standard of common reference is obvious in the undertaking of any comprehensive and far-reaching system of works.

The third topic is illustrated by a general basin map, and has been carefully compiled from original sources with a view to better determinations of the water areas and the actual watershed drains therein, and this work has had the cooperation of the Geological Survey of Canada in the definition of the little known watershed line through the highlands of Canada.

The fourth topic deals with the effect of gales on Lake Erie, and has a most important bearing on any proposition for the control of the level of this lake and the project for a canal therefrom to Lake Ontario. The available means did not permit the extending of this investigation to the other lakes, in which, however, the phenomena are less characteristic and less significant in their practical bearing.

The fifth topic has taken great research, and although the subject has not been exhausted, the results are valuable as an index of water conditions in the several lakes prior to any material disturbance of the watersheds due to inhabitation. It is to be inferred that extreme variations in water level were more pronounced than during recent times.

The important topics of rainfall and the outflow of the lakes and

their relation to each other and to lake levels have been quite beyond the resources of the Commission, and the data regarding outflow are very meager.

Exhibit C was designed to cover the practical topics governing most directly the character and utility of works, but as their consideration has naturally followed the development of the preceding schedules, little progress has been made except in relation to the ice season. This comprises a large number of tabular records for varying periods upon the streams and lakes of the United States and Canada, and the more significant features in their bearing on water routes are partially presented in five diagrams. This topic is compiled from material, the larger part of which has been collected for the first time from original sources, and is found to give systematic and consistent indications quite beyond any anticipations, considering the diverse character of the original observations and the various individual incentives for keeping these records. A very voluminous correspondence has led to the conclusion that it will be feasible to obtain a substantially complete record for a sufficient number of points to project general charts of the ice season and its variation with latitude, altitude, and water conditions, and the economic and scientific importance of such work can not be overestimated.

It is considered that these general exhibits are important, and that they should be published in full as the primary information for the many who have under advisement, or wish to consider, the questions herein treated.

SUMMARY OF DEDUCTIONS.

The leading deductions which are to be inferred from the work of the Commission are presented in the following summary:

They are tentative in part and ignore the boundary line and are intended to present in logical sequence the leading considerations which determine a choice of routes and the character of an enterprise as well as the collateral bearing of the same.

I. THE TRUNK ROUTE.

1. All routes are assumed to originate at the head of Lake Michigan at Chicago, and at the head of Lake Superior at Duluth-Superior, thence by Lake Michigan and the Straits of Mackinac and by Lake Superior and the St. Marys River, respectively, a junction is reached in Lake Huron. All deep-water routes to the eastern seaboard are restricted to two outlets, the St. Lawrence River from Montreal to the Gulf of St. Lawrence on the north, and the Hudson River from Troy to the Atlantic Ocean at New York.

2. From the junction in Lake Huron to Montreal and to Troy various routes and combinations of routes have been advocated by diverse interests:

(*a*) The natural route via Lake Erie, Lake Ontario, and the St. Lawrence River to Montreal, and via Lake Champlain to Troy, with an alternative line from Lake Ontario to Troy via the Oswego-Oneida-Mohawk Valley. An alternative to the Lake Erie route is the direct line via Georgian Bay to Lake Ontario at Toronto.

(*b*) The Ottawa route via the Ottawa and St. Lawrence rivers to Montreal and via Lake Champlain to Troy. This line omits Lake Erie and Lake Ontario.

3. The Georgian Bay line is not considered an available alternative for the Lake Erie route:

(*a*) The work of construction is much more serious, and the same

money will develop the Lake Erie route for a capacity which will more than offset the saving in distance.

(*b*) The water supply is limited for a navigation of the first class, the summit level being drawn upon in both directions, which exacts locks of moderate lifts. The excess of lockage, the number of locks, and the amount of restricted channel increase the commercial length or time on the route, the saving in distance being apparent rather than real.

(*c*) The ice season is sensibly longer on Lake Simcoe, the proposed summit level, and at Georgian Bay points.

(*d*) Lake Erie is the greatest traffic lake, and its position will always make it an important factor. The construction of an alternative line would not obviate the necessity of developing the Lake Erie route.

4. The Ottawa route is a short, independent line which may have great value for future development, but its consideration is not now justified:

(*a*) It is the shortest through route between terminals and is unquestionably adapted to a navigation of considerable capacity. Comprehensive surveys will be required to determine its availability for a navigation of the first class, and until a project has been matured it will be impossible to say how far lockage and restricted channels will offset the apparent saving in distance.

(*b*) For a large portion of its length it runs through a region meager in resources and the ice season is considerably longer than on the Lake Erie route.

(*c*) The function of the Ottawa route is as a future loop line for through business when traffic conditions shall have been sufficiently developed by the Erie-Ontario route; provided, it shall be found capable of a radical solution.

5. The routes for shortening distance between Lake Michigan and Lake Huron and between Lake Michigan and Lake Erie are available for a moderate capacity suited to the local and coasting trade. A first-class navigation, if practicable, would be very costly and its utility would be problematical. A large vessel would probably make the longer course through the open water as quickly and the land routes would be closed earlier by ice. They would open earlier in the spring, and this would be a positive advantage, unless means are devised for breaking the ice blockade at Mackinac.

6. A ship route through western New York along the general course of the Erie Canal is not regarded as a desirable project:

(*a*) It would involve 120 to 140 miles more of artificial channel than the route via the Niagara Ship Canal, Lake Ontario, and the Oswego-Oneida-Mohawk Valley; it would be crossed by a greater number of bridges and might have as many locks, owing to the conformation of the ground, and it would have a side hill location across lines of drainage for much of its course; all of which would make the route longer for navigation, more expensive to construct, and involve greater risk in maintenance.

(*b*) All the important points to be reached by such a project as Rochester, Cayuga Lake, and Syracuse, can be better and more cheaply served directly from Lake Ontario or by local canals.

(*c*) The country to be reached from both shores of Lake Ontario between Hamilton and Ogdensburg is an important consideration. Lake Ontario is comparatively isolated, and to join it with the upper lakes is conceived to be as fruitful in developing commerce as has been the union of Lake Superior, and a project for this purpose would be justified were there no possibilities of going farther in the direction of the seaboard.

(*d*) A moderate development of the canal through western New York with a high level through the central lakes basin may be of value as a means of water supply for a ship route through the Oswego-Oneida-Mohawk Valley.

7. The question of a trunk route is thus reduced to the natural course through the several Great Lakes. From Lake Ontario the St. Lawrence River leads to tide water at Montreal, and the Lake Champlain and Mowhawk routes lead to tide water of the Hudson River at Troy.

II. TERMINAL ROUTES.

8. The making of Lake Champlain a part of the Great Lake system is justified independently of any project for reaching the seaboard:

(*a*) The same considerations apply as in the case of Lake Superior and Lake Ontario, but in higher degree, on account of the very favorable position of Lake Champlain with respect to a distributive traffic through New England and the magnitude of the movement to and from this section.

(*b*) Except as opening up an increased territory, extension of navigation eastward gives very little advantage over Lake Erie for the transshipping and forwarding business until Lake Champlain is reached, which is more favorably situated for a part of the through service.

(*c*) An extension of lake commerce to Lake Champlain would add 40 to 50 per cent to the length of present lake routes, and a nearly proportional amount of territory in direct service, and would largely increase the total water movement. Lake Champlain is a normal part of the Great Lake system.

9. The St. Lawrence route is justified as a seaboard route on its merits and independent of all other considerations:

(*a*) Lake navigation at the head of the St. Lawrence rapids below Ogdensburg is 111 miles from ocean navigation at Montreal, with a present length of 46 miles of intermediate canals and 220 feet difference in level. The artificial channel required for a navigation of the first class is much less than that of either the Suez Canal or the North Sea-Baltic Canal. This route is capable of development to any useful capacity for much less money than any other.

(*b*) It is the shortest line for direct trade with the north of Europe to the maritime Provinces of Canada. It is recognized that the foreign movement is largely incidental to the lines of domestic commerce, and that by comparison the ratio of domestic movement in this direction is destined to be small; so the St. Lawrence route is not to be taken as a solution of the seaboard problem.

(*c*) Half of the work required to open the St. Lawrence route is also half of that required to reach Lake Champlain. Considering Lake Champlain as a part of the lake system justifying development, the cost of making the St. Lawrence outlet is very small in proportion to its probable utility. The works to reach Lake Champlain and to reach Montreal should be regarded as parts of one project.

10. The development of the St. Lawrence seaboard outlet and the making of Lake Champlain a part of the lake system in nowise lessen the importance of an outlet to the Atlantic seaboard through the Hudson River:

(*a*) The predominant seaboard movement on this continent is to and from the Atlantic Coast between Portland and Norfolk. This is likely to continue the major factor in domestic commerce and the controlling element in foreign movement.

(*b*) From Lake Erie northeasterly, the Lakes and St. Lawrence extend parallel to the trend of the Atlantic coast and at a distance of 250 to 400 miles. The detour via the Gulf of St. Lawrence to reach this coast is an average trip of 1,830 and 2,000 miles, as against feasible cross routes of 370 and 330 miles. If Lake Ontario were an arm of the sea, the situation would not be materially changed. In other words, for the movement in question, the St. Lawrence route would be of very doubtful utility.

(*c*) The situation is not unlike and more emphatic than that of France between the Mediterranean and the Atlantic, with physical conditions, such as France does not possess, inviting a water route of the first magnitude. The economic conditions warrant an expenditure several times that required for the St. Lawrence route.

11. With Lake Champlain in the lake system, engineering considerations favor the Champlain-Hudson route from the head of Lake Champlain at Whitehall to tidewater at Troy:

(*a*) By a cut through the Champlain-Hudson divide the level of Lake Champlain may be carried into the Hudson River Valley and locked down to tide level above Troy in a total distance of 64 miles. The entire route from Lake Ontario will be downhill and the lockage may be concentrated at three localities in maximum lifts.

(*b*) The tidal Hudson is favorable to deep-water improvement, the amount of material to be moved being no greater than has already been handled in the deepening of the St. Lawrence below Montreal, and the mileage of shallow water to be improved is considerably less. In fact, from the common point in Lake St. Francis to the open sea, the mileage of restricted channel by the Champlain-Hudson route is not excessive in comparison with that of the St. Lawrence route. The statements regarding the tidal Hudson are equally applicable to the Oswego-Oneida-Mohawk route.

(*c*) The Champlain-Hudson route is advantageous to eastern Canada as a short cut to the southern coasts and to the West Indies. It is the logical extension of a future Ottawa route should conditions favor a radical development on that line, and it skirts New England.

12. Economic considerations favor the Oswego-Oneida-Mohawk route from Lake Ontario at Oswego to tide water of the Hudson River at Troy, provided the physical conditions permit of a radical solution:

(*a*) The route from Oswego to Troy is 177 miles as against 379.5 miles by the St. Lawrence River and Lake Champlain, or 202.5 miles less in absolute distance. Were the Mohawk Valley in virgin condition it would be feasible to dam it near Amsterdam to the level of Oneida Lake and make a through cut of the Rome summit. Such a treatment would make the route as a whole equal to if not better than the slowest or more restricted 177 miles of channel on the St. Lawrence-Champlain route and save in time the equivalent of the remaining 202.5 miles. This saving on so large a proportion of the commerce as is destined to the Hudson River outlet will be a matter of great moment.

(*b*) To the extent that vested interests prevent a radical solution will the advantage of distance diminish by increase in the number of locks and through a more restricted channel. An endeavor to mold the works closely to existing conditions may actually destroy the advantage in distance without greatly reducing the cost for a navigation of the first class.

(*c*) The data show that the route is capable of development for a second-class navigation without radical disturbance of vested interests. The relative value of the route and the capacity to which it may be

developed must await final surveys and actual projects, considered on the basis of cost and of economic value. The profile and map, the first ever made of this route as a whole, suggest possibilities not heretofore anticipated, and warrant an exhaustive consideration from final data.

13. Each of the three routes from Lake Ontario seems to have inde pendent merits justifying its construction, and no one of them can be eliminated without sacrificing material advantages. It is easy to believe that the eventual growth of commerce will furnish business for all. Meantime, the determination of the route for initial development should rest on a consideration of all the factors in the problem.

III. LIMITING CONDITIONS.

14. The water supply is adequate to a project of any character on all available routes, except the Mohawk, which may require special provision:

(*a*) The mean outflow of the lakes at Niagara is adequate to a channel three-fourths of a mile wide and 40 feet deep, with a velocity of 1 mile per hour. Any proportion of this is available for the St. Lawrence and Champlain-Hudson routes.

(*b*) A through cut of the Rome summit to the level of the lakes of central New York, or a high-level feeder from Lake Erie, will provide a sufficient water supply for the Mohawk route; otherwise, a limited water supply will dwarf the project for a navigation of the first class, as the channel must be fed both ways from a summit, while on the other routes the feed is continuously in one direction.

15. Assuming 30 feet at standard low water as the limit of depth for a navigation of the largest useful capacity, the proportion of channel to be actually constructed or deepened on any of these routes is relatively small:

(*a*) In this consideration, it is assumed to be feasible to control the level of Lake Erie so as to produce 16 feet on the miter sill of the Welland Canal at Port Colborne, or raise standard low water 2.28 feet, by works placed in the Niagara River at Tonawanda and in the Canadian channel opposite, and that the Lake Erie level, less the slope required in the Niagara River, will extend to Tonawanda; and further, that the Niagara Ship Canal is to be constructed from Tonawanda to Lake Ontario at Olcott harbor, via Lockport.

(*b*) It is assumed that the St. Lawrence River below Montreal has been deepened to 30 feet. The present improvement is for a depth of 27.2 feet and covers a length of 43 miles of dredged channel. A depth of 30 feet involves 50 miles of work, and this has already been undertaken.

(*c*) It is assumed that the Hudson River below the State dam at Troy has been deepened to 30 feet. The project now under way is for 12 feet and covers 12 miles. A depth of 30 feet involves 31 miles of improvement.

(*d*) Between Lake Michigan and Lake Huron, through the Straits of Mackinac, the depth is ample; but a change in the sailing course will be required over a somewhat longer route. Between Lake Superior and Lake Huron, through the St. Marys River, a depth of 30 feet involves 27 miles of channel and 1 mile of the St. Marys Falls Canal.

(*e*) From Lake Huron to Lake Erie are 43.5 miles of channel of less than 30 feet; and between Lake Erie and Lake Ontario, 5.5 miles of channel and 25.3 miles of canal.

(*f*) From Lake Ontario to Montreal and to Troy the constructed and

deepened channel will be approximately as follows (the constructed channel may be classified as actual canal and as artificial channel formed by impounding water):

Routes.	Actual canal.	Artificial channel.	Deepened channel.	Total.
	Miles.	*Miles.*	*Miles.*	*Miles.*
St. Lawrence River to Montreal	42.5	20	16	78.5
St. Lawrence-Champlain to Troy	67	80	52.3	199.3
Oswego-Oneida-Mohawk to Troy	85	70	12	167

On the St. Lawrence-Champlain route, 20 miles of canal, 20 miles of artificial channel, and 9.8 miles of deepened channel are common to the St. Lawrence route; and 23 miles of canal, 20 miles of artificial channel, and 8 miles of deepened channel are between the St. Lawrence River and Lake Champlain.

The artificial channels are assumed equal in capacity to the deepened channels. How far this may be true and the relative extent of actual canal and of artificial channel depend on the treatment.

(*g*) From Chicago to Montreal and to Troy the proportion of work is as follows:

Character of work.	St. Lawrence route.	Champlain route.	Mohawk route.
	Miles.	*Miles.*	*Miles.*
Actual canal	67.8	92.3	110.3
Artificial channel	20	80	70
Deepened channel	65	101.3	61
Total work required	152.8	273.6	241.3
Total distance	1,281.5	1,460.5	1,258
Percentage	11.9	18.7	19.1

To the mouth of the Saguenay River and to New York City the proportion of work is as follows:

	St. Lawrence route.	Champlain route.	Mohawk route.
	Miles.	*Miles.*	*Miles.*
Total work required	202.8	304.6	272.3
Total distance	1,558.5	1,614.5	1,412
Percentage	13	18.9	19.3

The distance from Duluth is 67.5 miles greater than from Chicago, and the proportion of work may be computed as above from data under (*d*).

16. A channel of certain dimensions may be taken as practically equivalent to deep and open water. Without assuming it to have this actual value, a channel one-fourth mile wide and 40 feet deep is arbitrarily taken as free water for the purpose of comparing the length of free and restricted channels. The distances are taken from Chicago to the mouth of the St. Lawrence at Pointe De Monts and to the Atlantic Ocean at Sandy Hook light vessel. Duluth-Superior will have 67.5 miles more of distance and 48 miles more of restricted channel than Chicago.

Destination.	Restricted channel.	Total distance.	Proportion.
	Miles.	*Miles.*	*Per cent.*
Montreal	223.8	1,281.5	17.5
Gulf of St. Lawrence	333.8	1,698	19.6
Troy—Champlain route	341.3	1,480.5	23.4
Atlantic Ocean—Champlain route	407.3	1,642.5	24.8
Troy—Mohawk route	300.3	1,258	23.9
Atlantic Ocean—Mohawk route	366.3	1,440	25.4

In the above tables canal distances are included in restricted channel.

17. The capacity of canals required between Lake Erie and tide water of the Hudson at Troy may be increased two and a half times at an additional cost of 30 to 40 per cent:

(*a*) This statement applies to the canal work proper and assumes that channels in open water will be deepened progressively as demanded by commerce. The basis of comparison is a canal adapted to a vessel of a draft of 20 feet. A vessel of the same model and a draft of 27 feet will have approximately two and a half times the carrying capacity.

(*b*) It may be assumed that about 30 per cent of the cost of the smaller channel is represented by fixed charges that will not vary materially with the capacity. Half of the remainder is represented by deep cuttings, in which the increased cost will be about 40 per cent. The other half will represent shallow cuttings, embankments, structures, etc., at various ratios and averaging about 60 per cent increase of cost. The results are as follows:

Class of expenditures.	For draft of—	
	20 feet.	27 feet.
	Per cent.	*Per cent.*
Fixed charges	30	30
Deep cuttings	35	49
Ordinary work, structures, etc	35	56
Total	100	135

(*c*) This ratio is taken for the Champlain route, including that portion of the St. Lawrence necessary to it. It will be greater for the St. Lawrence route as a whole. The project for the Mohawk route is not sufficiently obvious for comparison, but if a radical solution is adopted the ratio will be about the same. The results will vary on different sections and with difference in treatment.

18. The deepening of channels in open water, when necessary, will be relatively a minor factor. The deepening of the St. Lawrence below Montreal, and of the St. Marys River and the passage between Lakes Huron and Erie, furnish sufficient precedent. The material for the most part yields to ordinary dredging operations, and alternative channels offer special facilities at the most serious rock cuts.

19. The question of depth and width of channels between the several lakes and to the seaboard is solely one of cost. Up to channels sufficient for a draft of 27 or 28 feet, every condition seems to lend itself. Beyond this limit the difficulties rapidly increase, and the proportion of restricted channel will be so large as to make the result of doubtful efficiency. Happily, there does not appear to be any economic reason in sight that seems to require provision for a larger draft.

20. The season of navigation is limited by ice, and this varies greatly in different years. The body of the several lakes is capable of winter navigation, and through navigation would be feasible if intermediate

channels could be kept open. The ice interruption differs for the several routes:

(*a*) The ice season for the St. Lawrence between Montreal and the sea is given by the record at Montreal. The average is from December 10 to April 19, a period of 130 days. The closing is due to the freezing of drift and anchor ice accumulations and holds out little hope that the season can be shortened.

(*b*) The average ice season for the Hudson River at Albany is from December 22 to March 26, or 94 days. The St. Lawrence-Champlain route is governed by the St. Lawrence at Ogdensburg and Lake St. Francis, which may be taken from December 15 to April 14, or 119 days. The data for Lake Champlain indicate the possibility of shortening this period by ten days to two weeks.

(*c*) The Mohawk route is governed by Oneida Lake with an average ice period from December 16 to April 7, or 112 days. The rivers are usually free before the lake is open, and the ice season can probably be shortened.

(*d*) Whenever Lake Ontario can be reached it will be possible to reach Lake Erie. Lake St. Clair is the controlling point between Lake Erie and Lake Huron, the ice season averaging from December 17 to April 5, or 109 days. The closing is about the same, and the opening about two weeks later than the Detroit River and west Lake Erie points, which are nearly the same as Albany. Whether this period can be abridged or not depends on how far Lake St. Clair is complicated by drift accumulations from Lake Huron. Lake St. Clair corresponds practically to Oneida Lake and the southern end of Lake Champlain, so it is possible to reach Lake Huron whenever it is possible to reach Lake Ontario.

(*e*) The average ice season in the Straits of Mackinac is from January 6 to April 15, or 99 days. It will thus be seen that through navigation is limited by the closing of Lake St. Clair and the opening of Mackinac, or from December 17 to April 15, a period of 119 days. The Mackinac ice is understood to be largely the accumulated drift, due to winds on on the two lakes.

(*f*) The ice season of the St. Marys River is from December 8 to April 11, or 124 days, as indicated by the record at the mouth of the river; from December 4 to April 25, or 142 days, as indicated by the opening and closing of the canal, and from December 3 to April 27, or 145 days, as indicated by the record at Sault Ste. Marie, Ontario. The canal record may be taken as the practical limit of ice for the river as a whole. This is over a month earlier and over a week later than at the Straits of Mackinac.

(*g*) A through route from Lake Michigan will be closed from December 16 to April 15, or 120 days, by the Mohawk route; from December 15 to April 15, or 121 days, by the St. Lawrence-Champlain route, and from December 10 to April 19, or 130 days, by the St. Lawrence route. From Lake Superior the period is 142 days, closing six days earlier and opening six days later than at Montreal. From Lake Huron the period is governed by the routes east from Lake Ontario.

(*h*) Ice boats are now in operation that will break 10 inches of solid ice at 5 miles per hour and claims are made of ability to handle 18 inches. The great car ferries operate across Lake Michigan and even across the Straits of Mackinac at all seasons and are able to break any field ice encountered and plow through several feet of drift ice. It would seem to require no great development of resources to reduce the ice period to 90 or 100 days from Lake Huron by either the Mohawk or

Champlain routes, and if Mackinac proves tractable this period will apply to Lake Michigan. It is possible St. Marys River would also yield to proper efforts, but no inducement can be held out for the St. Lawrence between Montreal and Quebec as conditions are now understood, unless it be feasible to prevent the actual closing of the river as has been suggested by a commission of engineers. If commercial necessities should ever so demand, means are likely to be found for still shortening the period, and the experience in high latitudes in the north of Europe is not amiss in this connection.

IV. CAPACITY.

21. It is assumed that the character of works is to be adequate to vessels of the most economical type, not only for the coasting or domestic trade, but also for the foreign movement, so that commerce may be carried on directly between lake ports and other domestic and foreign ports without transshipment:

(*a*) Vessels vary in size with the trade in which they are engaged and with the length of route. The ability to obtain cargoes and to deliver them at points capable of distributing or forwarding them promptly, combined with length of route, justifies the largest type of carrier, and these conditions obtain at the great ports only. There are many other ports at which the trade requires a more moderate type of vessel. In this consideration it is assumed that harbors are improved to meet trade requirements, and this has usually followed closely on actual needs.

(*b*) The opening up of the lake system to foreign commerce will increase the length of many important trade routes upward of 40 per cent, and will reach directly the producing and consuming interior of the continent, in which, relatively, the largest future growth is to be anticipated. These conditions will make advantageous the largest type of vessel found useful in any trade of the world.

(*c*) The present type of lake vessel is of flat bottom and broad beam, and is an outgrowth of the demand for large carriers on the small depth of water through the intermediate channels. The limit of economical carrying capacity seems not to have been reached even on the short lake routes. The type of vessel is not the most economical to construct and operate, and would doubtless be modified in favor of larger draft were there no limit to the depth of channelways.

22. The requirements as now defined demand a limiting draft of 27 or 28 feet:

(*a*) Thirty feet is now recognized as the standard depth for first-class harbor entrances. This is intended to provide some margin of depth, depending on the tide, against pounding the bottom in a seaway.

(*b*) The North Sea-Baltic Canal is built with a depth of 29.52 feet (9 meters). The North Sea-Amsterdam has a depth of 27.88 feet, and an eventual depth of 35.5 feet is projected. The Suez was originally constructed for 26.24 feet (8 meters), and is undergoing progressive enlargement and deepening. The Panama project adopted 27.88 and 29.52 feet in different sections, and the Nicaragua project 28 and 30 feet. Corinth and Manchester each has 26 feet. The North Sea-Baltic and the North Sea-Amsterdam may be taken as the latest type, with depths of 29.52 and 27.88 feet, respectively. To float the same boat in fresh water, these canals would require to be 30.3 and 28.2 feet in depth, on account of less density.

(*c*) In 1886 21.7 per cent of the vessels passing through the Suez

Canal exceeded a draft of 22 feet 11 inches (fresh water, 23.5 feet), the limiting draft being 24 feet 7 inches. In 1890, 29.3 per cent exceeded the above, and in 1895, 36.4 per cent. The limiting draft was fixed on April 15, 1890, at 25 feet 7 inches (fresh water, 26.3 feet). The proportion of large vessels between a draft (fresh water) of 23.5 and 26.3 feet has rapidly increased until in 1895 it was 36.4 per cent of the number and about 44 per cent of the tonnage, as inferred from the usual proportion between draft and tonnage. Half of this tonnage exceeded a fresh-water draft of 24.5 feet.

(*d*) Freight vessels are in commission with a loaded sea draft of 26 to 28 feet, equivalent to a fresh-water draft of 26.6 to 28.7 feet.

23. Assuming a fresh-water draft of 27 feet, equivalent to a sea draft of 26.3 feet, a good type of boat will have a breadth over all of 60 feet and a length over all of nine times the breadth, or 540 feet, with a cargo capacity of 11,000 to 15,000 net tons.

(*a*) Recent lake practice for freight carriers gives a coefficient of displacement of 80 per cent, or the above boat would displace 21,870 net tons. The same practice gives maximum cargo capacity at 68 to 75 per cent of the displacement. If taken at 70 per cent, the above boat would carry a maximum cargo of 15,309 tons. This type may be taken as the extreme limit.

(*b*) For general service the coefficient may be taken at 70 per cent and the displacement at 19,140 tons. With more machinery and fuel, the cargo ratio may be taken at 60 per cent, and the cargo capacity at 11,480 net tons.

(*c*) Some of the latest Atlantic liners have coefficients ranging in the vicinity of 60 per cent. Of twenty-three of these vessels built since 1880, eight exceed the above dimensions either in length or beam. This type is not considered of utility for future lake business.

24. The locks required for the above type of boat are assumed to have a depth of 28 feet on the sills, a breadth of 64 feet, and a net length of 560 feet, with lifts up to 40 feet where permissible:

(*a*) The above dimensions give a better leeway than with the boats of the Ogdensburg line, which are built for the locks of the Welland Canal, their extreme width being 3 feet less than that of the lock, while their length is but 1 foot less than its net length and their draft is practically the depth on miter sills.

(*b*) Each of the several canals can be so designed as to bring the locks in the same locality so as to save delay. The single individual lock is considered better than the fleet lock and can be operated more quickly, and the maximum facilities may be provided by duplicate locks.

(*c*) The lift of locks should be made as great as possible where conditions permit, as time is consumed by the number of locks rather than by the lift. It is believed to be practicable to construct quick-acting locks, with girder gates and lifts of 40 feet, and much of the canal work can be better laid out for large lifts.

(*d*) With the least possible number of locks, quick operation, and provision for the speedy handling of boats into and out of the lock, much of the objection on account of delays will be obviated.

25. The question of canal prism and channel depth is important, and aside from the question of lockage, the efficiency of works for vessels of the largest class depends thereon:

(*a*) The subject of ship resistance in restricted channels is a matter requiring comprehensive investigation in view of the proportion of such channels on lake-seaboard routes. In addition to a sufficient ratio of cross section of canal to the midship section of the boat and ample

width for two boats to pass, the shape of the section is important. Experience shows that within certain limits and with sufficient width of prism, depth beneath the boat is essential both to speed and carrying capacity.

(*b*) As a trial section a minimum prism of 10,000 square feet is suggested, or a ratio 5.6 times that of the lock prism and 6.2 times that of the boat, with a depth of about 20 per cent in excess of lock depth and 25 per cent in excess of draft of boat, say a depth of 33⅓ feet and a mean width of 300 feet. In some situations greater depth would be justified at the expense of width, and again other situations might make 30 feet expedient. The general proposition is that when depth is readily obtainable an increase will be advantageous, and this is relatively a small item of cost in the bottom of deep cuttings.

(*c*) In open water where the depth may be increased at any time, this is a matter of less importance, but depth here will greatly facilitate speed and steering qualities, a matter of importance in channels as crowded as are the intermediate channels of the lakes. On this account and uncertain drifting due to currents and wind, lake interests are asking for widths of 600 feet and more according to locality for submerged channels, and future conditions will doubtless make expedient a width of one-fourth mile with such depth in excess of draft as may be found readily practicable.

(*d*) Experience in navigating the Welland Canal shows that the bridges and other structures are a source of vexation, requiring great care in navigation. Every obstruction that checks speed involves loss of steering power and is to be avoided so far as may be possible.

V. PROJECTS.

26. In addition to a project for a navigation of the first class as developed in the preceding sections, a project for navigation of the second class corresponds to present lake development, to much of the coasting trade, and to a vast general commerce with minor ports of moderate harbor depths. It is assumed that such a navigation is satisfied with dimensions in vessels, locks, and canal prisms of three-fourths of those heretofore discussed:

(*a*) The vessel would have a length over all of 405 feet, a breadth of 45 feet outside, and a draft of 20¼ feet, with a displacement of 8,000 to 9,200 net tons, and a cargo capacity of 4,800 to 6,400 tons. The lock dimensions would be 420 feet by 48 feet, with a depth of 21 feet on sills. The minimum canal section would be 5,625 square feet, or a depth of 25 feet and a mean width of 225 feet. The character of work is set forth in the preceding discussion.

(*b*) The above dimensions cover the lake fleet, except a few exceptional boats built in the last two years for ore carrying and capable of loading to 20 feet. The largest of these have lengths of 426 to 438 feet, breadths of 45.5 to 48.27 feet, and will carry 6,300 to 6,800 net tons on 19 feet and 500 tons more on 20 feet. The boats for general service are now well inside the dimensions fixed, but no limit can be given for special trades or even the general service, notwithstanding all routes are inside of 1,000 miles. It is to be assumed, however, that there will always be a trade demanding vessels within the limits set.

(*c*) It will be seen by consulting the several profiles that the limiting depth at standard low water is, for the St. Marys River, 17.9 feet; Lake St. Clair, 18.8 feet; Lime Kiln Crossing, 19.3 feet, and Niagara River, 17 feet. By raising the level of Lake Erie as heretofore

described, over 21 feet would be given from Tonawanda to Lake St. Clair, Lake St. Clair would require another foot and the head of the river at Lake Huron nearly 2 feet. The St. Marys River will require a deepening of over 3 feet. The depth on the floor of the new lock is sufficient if changes can be made so as to utilize the limit, as in the Canadian lock opposite.

(*d*) The present limit to Lake Superior is 17.9 feet and between the other lakes 18.8 feet. By controlling the level of Lake Erie and by continuing the policy of channel deepening at the other points, the standard of 21 feet may be obtained, and all in line with the policy of ultimate development. The extension of this depth over any route to the seaboard involves no extraordinary works except in the construction of canals. As already set forth, these can be made in essential parts on an ultimate basis without extraordinary increase in cost.

27. As a measure of early utility and pending the execution of new projects, it might be feasible to so amend the Canadian canal system, now nearing completion, as to be adequate to nearly all the lake fleet as developed up to the recent deepening of main channel:

(*a*) The Lake Superior trade has developed on a depth of 14.2 feet at standard low water as defined on the lower platform of the lock of 1881, and that of the other lakes on about 14.5 feet. The depths on the sills of the terminal locks of the Welland Canal are 13.7 feet at Lake Erie and 14.3 feet at Lake Ontario, and the canal has been open since the spring of 1887. The St. Lawrence canals now constructing between Prescott and Montreal vary from 14.4 to 16.2 feet on the sills of the several terminal locks.

(*b*) No sufficient reason appears for the failure to develop a greater trade to Lake Ontario points except the length of the locks, as the upper lake boats had outgrown these before the enlarged canal was opened. The number of locks and the length of time in passage and the lack of an adequate outlet from Lake Ontario may have contributed to the result. The locks are 270 feet long between hollow quoins and 45 feet wide, with 14 feet on the sills.

(*c*) The boats of the Ogdensburg line are built to conform to the locks, and are 255 feet in length, or within 1 foot of the possible limit, 42 feet over all, and carry a cargo of 1,750 net tons, with a depth of 14 feet on miter sills. With 16 feet the cargo would be increased to 2,200 tons. If the locks had been 125 feet longer the cargo would be 3,600 tons, or more than double the present limit, and this is about the limit of the general service boat on the lakes until recently, and represents a very large fleet running in various lines.

(*d*) To raise the level of Lake Erie as already suggested provides 16 feet in the summit level of the Welland. Some of the terminal locks require no change and others may be increased, while a few will need alteration or rebuilding. To raise intermediate levels and lock walls and to lengthen the locks to 395 feet may not be practicable. The ease and cheapness with which this could originally have been done, considering its value, encourages the hope that it may still be feasible to amend the work in progress and completed. A St. Lawrence-Champlain canal could thus furnish an early and valuable service to New England points.

28. The project outlined contemplates a first-class navigation for the largest type of ocean carrier now in use and also a navigation of the second class adapted to the present interlake trade, to coasting, and to the secondary foreign movement. The several considerations advanced are designed to determine a policy in accordance with which all schemes of

work may be projected to some consistent and ultimate end that shall comprehend the greatest possible utility:

(*a*) It is conceived that with the progressive improvement of intermediate channels some of the capital works will be undertaken and that the development will be in the direction of extending the area of lake navigation as securing the largest immediate benefit from the investment. It is believed that this may be done in harmony with the ultimate policy without undue increase in cost. In other words, the Niagara Ship Canal could be built on the ultimate design, but deferring such work as can be developed progressively or built as required without detriment to the final plan. How far this may be feasible in respect to this and other works can only be told as a final project is matured from detailed information.

(*b*) These remarks apply to other capital works and also to the question of expediency involved in the improvement suggested for the present Canadian canal system and in that connection the immediate carrying out of the section of work between Lake St. Francis and Lake Champlain.

(*c*) The scheme of work is based on locks in two sizes and adapted to a navigation of the first and second class. At an early day after the completion of the work as a whole each of these types will require duplication, and before the movement has reached the proportions of that now existing through the Detroit River. It is not assumed that these types will exhaust the requirements. There are vessels in service in the merchant marine and in the Navy, sidewheel boats on rivers and sounds and tows for which a fleet lock may eventually be expedient. It is assumed, however, that the towing practice in certain trades on the lakes is simply the natural outgrowth of the economy of large carrying which must conform to limited depths and is in itself an argument for greater depths and the higher economy of the single hull. With the development of these greater depths the fleet tendency is likely to diminish.

29. The control of the level of Lake Erie is desirable if it can be accomplished by works in the vicinity of Tonawanda and on the opposite side of Grand Island, not only as an improvement of the rock channel near the mouth of the Detroit River, but especially as a measure of radical improvement for the Niagara River, and a contribution to the Niagara Ship Canal. It is believed to be justified solely in connection with the passage from Lake Erie to Lake Ontario:

(*a*) It has been suggested that standard low water on Lake Erie should be raised 2.28 feet. This figure is taken arbitrarily as corresponding to 16 feet in the Welland Canal, and is well within the limits of high water, so no extraordinary question of damages is involved, but otherwise is not necessarily a measure of what can or may be wisely done. With due allowance for the slope in the Niagara River, the water at Tonawanda would be raised 7 to 8 feet above standard low water.

(*b*) To accomplish the above result would require a material improvement in the throat at Black Rock and a deepening of 5 to 6 miles of river and entrance in order to secure 30 to 33 feet of water. The summit level of the canal between Tonawanda and the mountain ridge near Lockport would be materially reduced in excavation.

(*c*) The general route for the canal as proposed in 1889 seems preferable to any other, with a possible modification in favor of a location along the general course of Tonawanda Creek and the Erie Canal between the Niagara River and the "gorge" at Lockport. No other

route that has been surveyed from the Niagara River to a lower point has equal availability on account of the continuous rock bed and limited depth below Tonawanda and the impracticability of farther down-stream extension of the Lake Erie level.

(*d*) Most careful surveys and studies will be required to determine the actual practicability of the solution herein suggested. It is obviously desirable, and it is believed on superficial examination that it will be found within the domain of feasibility.

30. No experimental work is involved in the development of any useful depth through the intermediate channels of the upper lakes:

(*a*) In a route of over 900 miles between Chicago and Buffalo the obstructions to a depth of 30 to 33 feet are about 44 miles, or about the same as the improved St. Lawrence below Montreal on a depth of 27.2 feet. Of this, 18 miles are through Lake St. Clair, which is understood for the most part to be of the easiest class of dredging and not more difficult than was Lake St. Peters on the St. Lawrence. Ten to 11 miles are near the mouth of the Detroit River and in part is known to be rock. Methods for this work have been developed. If these are too tedious and expensive, it will be feasible to unwater the American channel and execute the work more quickly and satisfactorily and at less probable cost. The remaining 15 miles are scattered shoal stretches which are not known to involve any special difficulties.

(*b*) The route into Lake Superior through the St. Marys River involves some 27 miles of deepening aside from the canal. Portions of this are known to be a friable and laminated sandstone, which in part yields to dredging, and it is probable that machines would be devised to handle it efficiently if a radical improvement warranting the same were to be undertaken.

31. Eastward from Lake Ontario, the data are in part suggestive only, yet certain features are obvious and no extraordinary conditions are involved except in the magnitude of the works:

(*a*) The same dredging fleet that has through a series of years deepened the St. Lawrence below Montreal to 27.2 feet has only to continue in service as it is now doing to produce 30 and 33 feet. The improvement of Lake St. Louis and Lake St. Francis is the continuation of work of a different character, but of much less extent. The improvement of the shallows of Lake Champlain is believed to be less difficult, as the material in large part is probably alluvial. No reason appears why the Hudson River below the State dam at Troy should be more difficult as a whole than that of the St. Lawrence, and the extent of work is much less.

(*b*) The American shore along the rapids of the St. Lawrence between Ogdensburg and St. Regis seems to be most available for a ship canal of the first class, and it is anticipated that a full survey will develop special adaptation. Between Lake St. Francis and Lake Champlain, the southern route explored by Mr. Barstow seems to have advantages in being some 26 miles shorter than any other and with that much less of shoal water. Detailed surveys will be required to develop its merits. A ship canal from Lake Champlain to tidewater of the Hudson involves a formidable cutting and the damming of the valley above Waterford. Aside from its magnitude there does not appear any obstacles of moment, and the seriousness of these great cuttings, which has grown less formidable in the last few years, may greatly diminish on final study with a view to practical work.

(*c*) Little further can be mentioned in regard to the Mohawk route. The divide west of Little Falls is a filled-in valley, and this discovery

promises a better condition than heretofore assumed. The knowledge brought together in this investigation has developed a more favorable opinion respecting this line, but the best treatment is not yet obvious, and conclusions must await the test of final surveys and a matured project.

VI. MISCELLANEOUS.

32. The ice record is incomplete and general deductions are not warranted. Those records that have been continued for fifty to eighty years fail to disclose any systematic change such as would follow a change of climate, and it appears that the average ice season for any twenty years may be taken substantially as the average for any other twenty years or for any longer period. There seems to be quite a systematic and uniform increase in duration with latitude from 37 degrees north to the Canadian highlands, north of which the increase is slower. The course of rivers and streams and the character of the body of water are also influential. The normal variations have not been worked out.

33. The record of lake fluctuations is also incomplete. These records fail to show any change such as might be due to a change in precipitation and rainfall and the inhabitation of the watershed. It appears that the first half of the century had greater extremes of both high and low water than the last half in the region of the three upper lakes, while no special difference appears in the region of the lower lakes and the St. Lawrence. From 1815 to 1830 there appears to have been lower water in all the lakes than the period now passing, except Lake Champlain, which has had the lowest and highest water of seventy years within the last thirty. Conditions do not seem to be normally similar in all the lakes, and it is rare that all cooperate in a low or high water, which fact tends to equalize conditions.

34. No effects on levels have appeared from the progressive deepening of channels except at Montreal, where the water has been lowered locally by a foot or more, and this is obviously due to special conditions in the vicinity. Special study has not been given this matter, however, but it is anticipated that the radical improvement of the passage between Lake Huron and Lake Erie will produce a sensible effect on the level of Lake Huron-Michigan. As most of this effect will occur in the delta of the St. Clair and in the lower reach of the Detroit River, it may be largely masked by the raising of the level of Lake Erie. The improvement of the St. Mary's River may have lowered the water at the locks, and this effect may be anticipated from further enlargement. The radical project herein considered will bring the level at the locks well down toward the level of Lake Huron.

35. The raising of Lake Erie by 2.28 feet will raise the level of Lake St. Clair by about 1 foot, so far as can be inferred from a study of gauge relations, and the effect would disappear at the head of the St. Clair delta. The investigation has, however, not been sufficient for a final determination so as to conclude the matter. No sufficient reason has appeared for the control of the level of the lakes other than Erie, and this is justified in large part in connection with the Niagara Ship Canal.

36. It may be said in regard to future works of navigation that experience in the last few years in this country and Europe has been revolutionary in the development of appliances and in the methods for handling large cuttings, and these can now be undertaken with confidence both as regards cost and time of completion; and, further, that canals in rock cuttings can be so planned as to cost but little more per mile than in the kind of drift so common to canal locations. Further

advances in earth removal are to be anticipated in some favorable situations. In under-water work the advance has been notable, and much is yet to be anticipated from the further development of hydraulic dredging. Machines are also in operation capable of handling many kinds of friable and stratified rock. In construction, a desirable advance has been made in the direction of monolithic masonry, which is cheaper and much superior for much of the work in question, and most anything may be attempted in the way of metals. While recent developments have furnished tried resources for every problem, the next series of great works is likely to produce further advances, so that no doubt need exist on the practical side in execution.

The mistakes, if any, are likely to occur from not having considered sufficiently all elements of the problem, and in works of such extraordinary magnitude an error involves a cost in comparison with which any mere cost of proper data and consideration thereof is a vanishing quantity.

CONCLUSIONS.

After considering this question in its various aspects, we conclude—

First. That it is entirely feasible to construct such canals and develop such channels as will be adequate to any scale of navigation that may be desired between the several Great Lakes and to the seaboard, and to conduct through the same domestic and foreign commerce, and that, in our opinion, it will be wise to provide for securing a channel of a navigable depth of not less than 28 feet.

Second. That starting from the heads of Lakes Michigan and Superior, the most eligible route is through the several Great Lakes and their intermediate channels and the proposed Niagara ship canal (Tonawanda to Olcott) to Lake Ontario; and that the Canadian seaboard may be reached from Lake Ontario by the way of the St. Lawrence River, and the American seaboard may be reached from Lake Ontario by way of the St. Lawrence River and Lake Champlain and the Hudson River, or by way of the Oswego-Oneida-Mohawk Valley and the Hudson River.

Third. That the alternative routes from Lake Ontario to the Hudson River require complete surveys and a full development of economic considerations to determine their relative availability.

Fourth. That a moderate control of the level of Lake Erie and of the Niagara River above Tonawanda may be justified in connection with the Niagara ship canal, the determination in this matter to rest on a full examination of the physical conditions.

Fifth. That the policy should contemplate the ultimate development of the largest useful capacity, and that all works should be planned on this basis, and that the actual execution should conform thereto, except in so far as the works may, without prejudice, be progressively developed with the actual demands of commerce.

Sixth. That it is practicable to develop the work in separate sections and the several sections in part by degrees, each step having its economic justification, so that benefits shall follow closely on expenditure, without awaiting the completion of the system as a whole.

Seventh. That the completion of the entire system as quickly as proper projects can be matured and economically executed is fully justified.

Eighth. That the Niagara ship canal should be first undertaken, and incidentally the broadening and further deepening of the intermediate

channels of the lakes, the same being in the logical order of development, and also requiring the least time for consideration.

As collateral to the main questions, and in view of the magnitude of the interests involved, the exhaustive consideration of all physical conditions that may determine the effects of proposed works or influence the character or features of a design should be concluded, but this need not delay the inception of plans or the beginning of work, but is likely to bear upon the manner of their completion. It is usually practicable to supply sufficient elasticity in design to meet any margin of uncertainty involved in these considerations.

In view of the international character and relation of a part at least of the works that will be required and of riparian interests involved, it seems expedient to make the examinations and projects and carry on the works through a commission that may be possessed with certain limited international functions.

Specifically, the matters which call for early action may be epitomized as follows:

RECOMMENDATIONS.

I. That complete surveys and examinations be made and all needful data to mature projects be procured for—

(*a*) Controlling the level of Lake Erie and projecting the Niagara ship canal.

(*b*) Developing the Oswego-Oneida-Mohawk route.

(*c*) Developing the St. Lawrence-Champlain route.

(*d*) Improving the tidal Hudson River.

(*e*) Improving intermediate channels of the lakes.

II. That the collecting and reducing of existing information, supplemented by reconnoissances and special investigations, be continued until the general questions have been fully covered.

III. That a systematic measurement of the outflow of the several lakes and a final determination of their levels shall be undertaken.

IV. The complete surveys and investigations, with measurements of the outflow of the several lakes and full investigation of collateral questions, will cost not less than $600,000 and require some years of time.

It is possible that the measurement of the outflow of the lakes and the final levels can be as well done through some other agency, and this item may be taken at $250,000, to be expended through a series of years, and this should be at once undertaken on account of the prevailing low water of the lake system, which can not be expected to continue.

The specific surveys and investigations are in themselves estimated at $350,000 and will take two or three years, and of this not less than $150,000 should be appropriated the first year, along with such additional sum as may be required for measuring the outflow of the lakes, of which $100,000 should be made available during the first year.

Respectfully submitted.

JAMES B. ANGELL.
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REPORT ON TECHNICAL WORK.

BY

L. E. COOLEY, C. E.,
UNITED STATES DEEP WATERWAYS COMMISSION.

CHICAGO, DECEMBER, 1896.

REPORT ON TECHNICAL WORK.

INTRODUCTION.

At the January meeting of the Commission it was recognized that the means placed at its disposal were inadequate to the entire subject-matter. It was therefore decided, so far as practicable, to make a systematic presentation of existing data, supplemented by special inquiry and reconnoissance where the same was known to be deficient. It was assumed that thereby certain general conclusions would be obvious, the possibilities would be developed, and the character of a project so far determined as to justify recommendations in regard to the final surveys and investigations for a specific project, with estimates of cost.

The scope of the work was considered in outline and the duty of carrying out the same was intrusted to the writer. The scheme of topics has been elaborated into the several schedules hereinafter presented.

Work began on February 1 with a small force of assistants skilled in this kind of research, and was vigorously pushed in the expectation that such matter could be prepared as would warrant the Congress then in session in further appropriation. By the end of May a report was deemed inexpedient, and the investigation has been followed since with a reduced force.

A great mass of information has been brought together and digested. Nevertheless the ground has not been covered as fully as anticipated. For many years the writer has been following the line of inquiry and has supervised investigations in several directions, and the field of these former explorations was rapidly covered. No sufficient credit was given for the time and labor involved in these earlier researches, and consequently the newer topics have been quite underestimated. Had the appropriation been adequate to a larger force it is probable that the work mapped out would have been completed, as topics which have not been reached could have been taken under advisement. At the same time, some topics require time which no increase of force could reduce.

It was recognized at the outset that all matters germane to the inquiry could not be considered and efforts were therefore largely restricted to those topics about which the least is generally known by those who are called upon to consider the subject of this inquiry. It was also deemed wise at this stage to make data exhibits only and to defer conclusions until all essential or obtainable evidence had been examined.

SCOPE OF THE WORK.

The topics requiring consideration have been arranged in four characteristic schedules.

The first of these was designed to present, by means of profiles and maps, the physical conditions on all routes which have been considered

as available for waterways between the several lakes and from the lakes to the Atlantic seaboard.

The second schedule pertained to the hydrology of the basin of the lakes and of the St. Lawrence and Hudson rivers.

The third schedule related to a class of topics which determine the character of a project and the relative utility of routes.

The fourth schedule was to embrace the historical, statistical, and economic topics which justify an undertaking.

No special work has been undertaken under the fourth schedule. The bearing of these topics is better understood than those of the other schedules, and the inferences therefrom are subordinate to the physical determinations. This schedule was therefore deferred. Some topics of the first schedule are incomplete for lack of data, but these are of a subordinate character, in nowise affecting conclusions. Two important topics of the second schedule have not been undertaken, owing to the amount of work involved and to insufficient data. Only one topic of the third schedule has been developed beyond the preliminary stage, but this has probably taken more time and labor than would be required for the other topics.

EXHIBIT A.—PROFILES AND MAPS OF WATER ROUTES.

The first exhibit, known as Exhibit A, is represented by a general report and two special reports and fifteen sheets of drawings showing maps and profiles, designed to illustrate the physical conditions existing on various routes and sections of routes between Chicago and Duluth-Superior and the Atlantic seaboard by way of the Hudson and St. Lawrence rivers. The main profiles are drawn to a uniform scale, while subordinate routes, or those about which the data are meager, are shown to a minor scale, all being referred to mean sea level. The authority for the several profiles is fully set forth on the drawings and in the notes accompanying the same. The following is the exhibit:

THE LAKES AND ATLANTIC WATERWAY.

Chicago and Duluth-Superior to the seaboard.
Through the Great Lakes and by the St. Lawrence River and by the Hudson River.
Notes of explanation to accompany profiles and maps.
Report on Oswego-Oneida-Mohawk route.
Special report on reconnoissances—St. Lawrence-Champlain route.

PROFILES AND MAPS.

1. General profile. With distance diagram.
1a. General-route map.
2. Lake Superior to Lake Huron.
3. Lake Michigan to Lake Huron.
4. Lake Huron to Lake Erie. With sketch and profile—St. Clair and Erie ship canal.
5. Lake Erie to Lake Ontario. With outline map.
6. Lake Ontario to Lake St. Francis, through the St. Lawrence River. With outline map.
7. Lake St. Francis to Lake Champlain and to Montreal. With outline map.
8. St. Lawrence River from Montreal to deep water below Quebec.
9. The Champlain-Hudson Valley from St. Johns, Province of Quebec, to Troy Dam, New York.
10. Hudson River from Troy Dam to Atlantic Ocean.
11. Lake Ontario to Hudson River through the Oswego-Oneida-Mohawk Valley.
11a. Map (same), with profile showing also Champlain-Hudson Valley.
12. Georgian Bay to Lake Ontario through Lake Simcoe. (Half scale.) With outline map.

13. The Ottawa route, from Georgian Bay to Richelieu River. (Half scale.)
14. Early canal systems. (One-fourth scale.) Erie of New York, United States; Rideau-Trent of Ontario, Dominion of Canada.
15. Interlake routes. (Not delineated.) Superior and Green Bay Canal; Grand Saginaw route; Michigan and Erie route.
Western New York. (No profile.)
New York and Pennsylvania. (No profile.)

It was discovered at an early day that the data for a preliminary profile by the Oswego-Oneida-Mohawk Valley from Lake Ontario at Oswego to the Hudson River at Troy was entirely insufficient. The cooperation of Mr. William Pierson Judson, of Oswego, N. Y., was secured in the compilation of existing data and in securing further data in the field, which has enabled a map and profile of high degree of accuracy to be produced. Although the utility of this valley for ship-canal purposes has been discussed for a long time, this is the first attempt to show its physical features by a map and profile.[1] Mr. Judson's map also shows the Champlain-Hudson Valley.

The data for a route from the St. Lawrence River at the foot of Lake St. Francis to Lake Champlain was also very unsatisfactory. The Deep Waterways Commission of Canada[2] undertook careful surveys via St. Johns and the Richelieu River, but the results were received too late for incorporation in the exhibit (profile No. 7) further than to determine the route on the map. Meantime a reconnoissance was made for the Commission by Mr. F. M. Barstow, of Burlington, Vt., of a route farther south and some 26 miles shorter. This route follows the valley of English River and Norton Creek, and, crossing the intermediate ridge, enters the valley of the Great Chazy River west of Rouses Point, and reaches Lake Champlain 7 miles south of the international boundary. This reconnoissance has developed a very promising line, which justifies a comprehensive survey.

A reconnoissance was also made for the Commission by Mr. Barstow of the south shore, along the rapids of the St. Lawrence, between Ogdensburg and St. Regis, and it is apparent that the availability of this territory for ship-canal location should be tested by proper surveys.

A preliminary reconnoissance was made of what is known as the "South Bay route," at the head of Lake Champlain and between South Bay and Fort Ann, but without significant results.

Special reports are submitted upon the Oswego-Oneida-Mohawk route and upon reconnoissance pertaining to the St. Lawrence-Champlain route.

The exhibit omits certain subordinate profiles for which the data were unobtainable with the means at command.

It was proposed to delineate three "Interlake routes" which had been suggested for shortening distance, all leading from Lake Michigan and terminating respectively in Lake Superior, Lake Huron, and Lake Erie; also a route through western New York for a ship canal or for a feeder for the summit level of the proposed Oswego-Oneida-Mohawk Canal. A route from Lake Ontario south to Chesapeake Bay via the valley of the Susquehanna was considered worthy of delineation.

The complete exhibit as outlined would have covered all practicable suggestions in regard to routes capable of varying degrees of develop-

[1] The Commission was furnished with an approximate profile by Hon. Campbell W. Adams, State engineer and surveyor of New York, through Mr. William J. Himes, division engineer Erie Canal. Mr. Himes's profile was utilized by Mr. Judson.
[2] A profile of the St. Lawrence River proper was also furnished through Mr. Thomas Monro, member.

ment. While such a presentation would make obvious the truly significant routes for deep water, accentuate their merits, and show by contrast the narrow limits governing a choice, the routes of special merit for first-class development are fully covered.

EXHIBIT B.—HYDROLOGY.

This schedule is represented by five topical reports, illustrated by nine sheets of maps and diagrams. The exhibit is as follows:

1. Elevations for the Great Lakes and for the St. Lawrence and Hudson rivers. (Manuscript, in four parts.)
2. Water levels for the Great Lakes and St. Lawrence River, 1860–1895. (Manuscript; tables, 15 in number, with supplemental table for 1896; diagrams, Nos. 1, 1ª, 2, 3, and 4, 4 in number.)
3. Basin of the Great Lakes and of the St. Lawrence and Hudson rivers. (Manuscript and map.)
4. Effects of gales on Lake Erie. (Manuscript; diagrams, three in number.)
5. Water levels for the Great Lakes and St. Lawrence River prior to 1860. (Manuscript, including tables.)

6 and 7. Rainfall and discharge. (Not taken up.)

One of the first things to be investigated was the subject of elevations with a view to a common plane of reference for profiles and water levels throughout the water system under consideration. The text shows that this has been done with such accuracy, that material changes in elevation are not to be expected from future leveling. There has been added to this discussion, for purposes of reference, special elevations and planes and a list of harbors with their depths and that of improved channels and canals.

The compilation of the tables of water levels since 1860 has required much care, and these have been verified by comparisons with the original records in the several engineer offices. A standard low water has been determined, which was designed to represent the same navigation value throughout the entire water system, and to this all profiles have been reduced. As will be seen by consulting the harbor, channel, and canal list in the first topic, a great variety of planes have been in use in the several districts and in works undertaken at different times, and for any scheme of general development on through routes it was necessary to determine a plane having a uniform value throughout.

The third topic gives the result of measurement of the very best available maps in the United States and Canada. The watersheds have been defined through the Canadian highlands by the office of the Canadian Geological Survey, and although there is some uncertainty in portions of this territory, the results given are likely to be as good as can be obtained until actual surveys are made of those little-known regions.

The fourth topic is a most interesting discussion by Mr. William T. Blunt of wind effects on the level of Lake Erie, and is a kind of research which should be extended to the other lakes. This, the money available did not permit. The effects on Lake Erie are more characteristic than elsewhere, and the subject has added importance in view of the proposition to regulate the level of this lake.

The fifth topic relates to the water record prior to 1860. This is the first attempt at a complete compilation of the available data. Original records have been referred to wherever possible. It is believed that further information will reward an exhaustive research, and that when all possible data have been collected and digested, important conclusions may be drawn in regard to the conditions existing prior to the inhabitation of the watershed in comparison with the present. As the final completion of this topic may involve several months, the results are presented in hopes that thereby new sources of data may be discovered.

The distribution of rainfall and its relation to lake fluctuation is a subject of much interest, but in view of the very great labor and time required to handle this topic it has not been undertaken.

The outflow of the lakes is a matter of primary importance in regard to which the data are very meager. A study of the available material has been made on former occasions, and the discussions are accessible.[1] Some new material has since been obtained, but it has not been possible to undertake a new digest of existing information, which is admitted to be very unsatisfactory.

The whole question of the outflow of the lakes and its variation with stages of water—and its relation to rainfall as well—is conceded to be of the very first importance. Many conclusions are thus left to inference which demand the most complete demonstration—a condition that is intolerable, considering the magnitude of the questions involved.

A knowledge of the above series of topics is essential in order to value the effect of any projected work upon these bodies of water and on riparian interests of very great magnitude.

EXHIBIT C.—PRACTICAL PROBLEMS.

The topics under this schedule are as follows:

1. The ice season, basin of the Great Lakes and surrounding territory. Notes; tables, 176 in number and general data; diagrams, 5 in number.
2. Winter commerce. Notes. (Not completed.)
3. Steam-carrying fleet. Dimensions and draft. (Not completed.)
4. Resistance of ships in restricted channels. (Not completed.)
5. Canal prisms, locks, methods of construction. (Not taken up.)

The first topic only has been sufficiently completed to warrant presentation. It comprises 176 tables and 5 diagrams. This has involved very great research and extensive correspondence. The topic has developed with the progress of the inquiry and is regarded as eminently worthy of further and exhaustive research. The subject has given rise to many new ideas and its practical and scientific importance can not be overestimated. It is found that heretofore very little systematic data have been collected in this field. It has not been thought wise to attempt general conclusions until the data could be more fully digested and reenforced by further records from inland points.

Preliminary consideration has been given to the other topics in preparation for a systematic investigation and some general ideas formed, which, however, are entirely tentative.

The subject of winter commerce is likely to develop possibilities quite unanticipated, except by the very few who have had some practical experience in this direction, and the season of ordinary navigation may be materially prolonged.

No general compilation has been made of the steam-carrying fleet giving outside dimensions and proper draft, and no sufficient study has been given the matter in its relation to the future development of the lake, seaboard, and foreign traffic.

The resistance of ships in restricted channels is in itself a matter of prime importance, not only in determining the relative value of routes, but in fixing the dimensions and character of channels that should be provided. The existing knowledge on this subject is at best in very unsatisfactory shape, and special data may be required for a proper solution. The matter has been pursued far enough to indicate the necessity for a radical revision of the old formulæ. In view of the amount

[1] Journal of the Association of Engineering Societies, March, 1889. Report of the Chief of Engineers, U. S. A., 1893, page 4364.

of canal prism and shallow water incident to any route for first-class navigation, the matter requires exhaustive treatment if results are to be obtained which may not prove disappointing.

The subject of canal prisms and locks and methods of construction is undergoing a revolution, the outcome of which is likely to render projects practicable which heretofore have been regarded as a little more than visionary. A discussion has not seemed warranted until the investigation of antecedent topics has determined the requirements.

It will be perceived that Exhibit C is the key to practical conclusions, though conforming in their application to the conditions developed under the topics of Exhibits A and B.

GENERAL REMARKS.

A careful consideration of the matter presented under the foregoing heads makes clear the real magnitude of the inquiry and the need of a comprehensive presentation of the physical conditions to be dealt with in any proposition for the radical development of navigation. In view of the very great proportions of the problem and the large cost of any radical development and the relation of such a development to the future of the country, it has seemed frivolous to venture mere opinions, and it has been preferred to develop the data topics as fully as the means would permit, in the expectation that thereby the main questions would be obvious to the discerning.

In undertaking this investigation, it was not anticipated that it would be feasible to more than collate existing material and clear up the general subject, so that the direction of final surveys and inquiries could be pointed out. This may be done at least tentatively and in part.

In closing this report I must commend the uniform interest shown in the work by persons in official and private station. Every request for data has met with prompt and full response, often at the cost of much labor and time. Had it not been for this, the inquiry would have been fruitless in many directions. What this means may be inferred from the fact that some of the material furnished runs back thirty to forty years, and has required much care in reduction. Pains have been taken in the drawings and manuscripts to credit this data to the proper authority.

I must also commend the devotion and ability of my assistants, Edgar Williams, A. E. Kastl, J. E. Maloney, and Charles Poore, and the skill and care of my draftsmen, G. A. Lichtenburg and Hermann Heinze. Although I have given all the work my close personal supervision, this does not detract from their credit for whatever merit may attach to the matter submitted.

The Commission is under special obligations to Maj. W. S. Stanton, Lieut.-Col. Jared A. Smith, and Capt. Smith S. Leach, in permitting the cooperation of their assistants, Mr. William Pierson Judson, Mr. William T. Blunt, and Mr. F. M. Barstow, when not occupied with official duties, and these gentlemen have rendered service of high character at very little cost.

I take pleasure in acknowledging the uniform courtesy of the several departments of the Canadian Government in responding fully to every request for information.

Very respectfully submitted,

LYMAN E. COOLEY.

Dr. JAMES B. ANGELL,
Chairman Deep Waterways Commission.

EXHIBIT A.

THE LAKES AND ATLANTIC WATERWAY.

CHICAGO AND DULUTH-SUPERIOR TO THE SEABOARD, THROUGH THE GREAT LAKES AND BY THE ST. LAWRENCE RIVER AND BY THE HUDSON RIVER.

NOTES TO ACCOMPANY PROFILES AND MAPS.[1]

Profile No. 1. General profile. With distance diagram.
Map No. 1a. General-route map.
Profile No. 2. Lake Superior to Lake Huron.
Profile No. 3. Lake Michigan to Lake Huron.
Profile No. 4. Lake Huron to Lake Erie. With sketch and profile—St. Clair and Erie Ship Canal.
Profile No. 5. Lake Erie to Lake Ontario. With outline map and sketches of alternative routes.
Profile No. 6. Lake Ontario to Lake St. Francis, through the St. Lawrence River. With outline map.
Profile No. 7. Lake St. Francis to Lake Champlain and Montreal. With outline map.
Profile No. 8. St. Lawrence River to deep water below Quebec.
Profile No. 9. The Champlain-Hudson Valley, from St. Johns, Province of Quebec, to Troy Dam, New York.
Profile No. 10. Hudson River from Troy Dam to Atlantic Ocean.
Profile No. 11. Lake Ontario to Hudson River, through the Oswego-Oneida-Mohawk Valley.
Map No. 11a. Map of the Oswego-Oneida-Mohawk Valley, showing also the Champlain-Hudson Valley.
Profile No. 12. Georgian Bay to Lake Ontario, through Lake Simcoe. With outline map.
Profile No. 13. The Ottawa route, from Georgian Bay to Richelieu River.
Profile No. 14. Early canal systems. Erie of New York, United States; Rideau-Trent of Ontario, Dominion of Canada.
Profile No. 15. Interlake routes. (Omitted.) Superior and Green Bay, Grand-Saginaw, Michigan and Erie.

INTRODUCTION.

A series of profiles and maps has been compiled for the purpose of exhibiting the possibilities of deep-water routes through and between the several lakes and by the St. Lawrence and Hudson rivers to the Atlantic seaboard. This series comprehends the lines of past development, of works now in progress and proposed, and the lines feasible for future development, including alternative routes and loops for shorten-

[1] Compiled in the office of the Commission from memoranda made in working up the several profiles and maps for the United States Deep Waterways Commission, Chicago, August, 1896.

ing distance. The object is to present once for all, regardless of relative merit, an exhibit of all routes having any elements of feasibility, for uniting the several lakes and reaching the eastern seaboard. All routes for merely tributary projects, or for connecting the lakes with other water systems, have been excluded.

This work has involved some new examinations in the field and a painstaking research for the data of early surveys, and has required great labor and patience in digesting the material and reducing the same to a uniform standard for presentation. But for the cordial cooperation of all in custody of original information, the work would not have been practicable.

These notes are intended to catalogue the several profiles and maps of the series and to authenticate and explain such matter as may not otherwise be sufficiently exhibited.

In entering upon the work, the necessity of deducing standard water levels that would have an equivalent value throughout the bodies of water traversed by the profiles was apparent. For the seaboard, the level long since adopted is mean low tide. For the several lakes and the St. Lawrence, the standard low water is deduced from the record of the thirty-six years from 1860 to 1895.

The plane of standard low water is the plane at or below which monthly mean water has stood not more than an aggregate of ten months during the season of navigation, which excludes the months of January, February, and March out of the aggregate of eighteen lowest monthly mean waters occurring during the period of thirty-six years, 1860 to 1895. To this plane all the profiles of water surface have been reduced. The deduction of standard low water is fully elucidated in the "Notes on water levels for the Great Lakes and St. Lawrence River."

Actual standard low water is a plane at or below which the water has ranged for six to ten months, out of a total of three hundred and twenty-four months, or for 2 to 3 per cent of the navigable period of thirty-six years. Longer records do not indicate that the ratio will be materially changed.

The standard high water as adopted on the several profiles is the highest water of record for the several lakes and rivers, as set forth in the "Notes on water levels," etc.

The elevations used on the several profiles are also set forth in "Notes on water levels," etc., and the manner in which these are derived is specially treated in "Elevations for the Great Lakes and St. Lawrence and Hudson rivers."

The main profiles have all been platted to a uniform scale; approximately, 2½ miles to 1 inch horizontal and 25 feet to 1 inch vertical. Subordinate profiles and those lacking data to justify the standard scale, are platted to one-half or one-fourth scale.

The explanations necessary to the understanding of each profile and map of the series are entered thereon. These notes add such further memoranda as will enable those who may be interested to verify any data used and the application of the same.

In making up the profiles all projects and treatment have been omitted, the purpose being to submit conditions as they now exist in nature or as they may have been modified by works actually executed. In the improved channels the original bottom is shown in outline. The entire exhibit is the data for consideration, rather than the consideration itself, which requires several other lines of information.

These notes have been compiled from the memoranda of the assistants who worked up the several profiles and maps.

GENERAL PROFILE.[1]

(Profile No. 1, accompanied by route map and distance diagram.)

The general profile is made to one-fifth the standard scale.

The profile extends from the head of Lake Michigan at Chicago through the lakes, Michigan, Huron, Erie, and Ontario, the St. Lawrence River, Lake Champlain, and the Hudson River, and through the several intermediate channels and canal routes by which the same are or may be joined in one continuous route to the Atlantic Ocean at New York. The profile of the route from the head of Lake Superior at Duluth-Superior to a point of junction in Lake Huron and of the St. Lawrence River from the point of junction in Lake St. Francis to the mouth are also shown, thus exhibiting a continuous profile from the head of Lake Superior to the Gulf of St. Lawrence. The profile of the Oswego-Oneida-Mohawk route from Lake Ontario to the Hudson River is shown as an alternative line for the Atlantic terminus, and is platted westward from the point of junction at Troy Dam. In the margins are shown the distances from Chicago and from New York.

The profiles were reduced from the standard profiles which have been compiled to illustrate special divisions of the several routes which may require treatment. The intermediate sections were filled in from the general charts of the lakes and St. Lawrence as issued by the Lake Survey, United States Army, and Hydrographic Office, United States Navy. In compiling these intermediate sections the termini of the special profiles were first laid down and the sailing route drawn in. The distances and depths were then taken off in the usual manner.

The general route map (map No. 1a) is a sketch or outline to illustrate the several routes over which profiles have been made. The routes of the general profile are shown by a broad band which is changed into two parallel lines at the last descent or point requiring locks in the approach to the sea.

The alternative routes available for a portion of the through lines, and for which subordinate special profiles have been made, are shown by broken bands.

Narrower bands or lines show the location of the several minor routes and profiles, those in use by full lines and those proposed by broken lines.

There has been added to this map, so far as its limits would admit, tributary water routes; those in operation and those abandoned, and projects now under way, and those actually adopted for construction. Projects not yet beyond the promotion stage have been omitted.

The distance diagram is platted on the same sheet as the general profile. It shows by three diagrams the main combinations to be made by three alternative routes, viz, Lake Erie route, Georgian Bay route, and Ottawa route.

The main diagram is that of the Lake Erie route, and it makes apparent at a glance the relative distances between various important points from Chicago and Duluth-Superior out by the St. Lawrence River, and by both the Champlain and Mohawk lines out by the Hudson River. The diagram by the Georgian Bay route shows the same combination of terminal lines. The diagram by the Ottawa route omits the Mohawk line in the combination.

[1] The general profile, general route map, and distance diagram were compiled and drawn by Mr. C. E. Isbell.

These diagrams represent the actual distances as developed in pro filing the several lines, and the principal items are entered in figures on the diagrams. A table is appended to these notes giving a fuller schedule of the distances developed.

LAKE SUPERIOR TO LAKE HURON THROUGH THE ST. MARYS RIVER.

(Profile No. 2.)

This profile, compiled by Mr. Edgar Williams and drawn by Mr. G. A. Lichtenberg, shows the available depth of water through the St. Marys River from deep water of Lake Superior to deep water of Lake Huron. The route begins near the southeast corner of Lake Superior, 1¼ miles northeast of Whitefish Point, and runs in a direct line to a point 1§ miles northeast of Point Iroquois, and thence follows the line of deepest water through the river, canal, and improved channels to Point Detour Light, at the northern entrance to Lake Huron.

The water-level elevations of Lake Superior, St. Marys River, above and below the locks, and Lake Huron, were determined by Mr. A. E. Kastl. (See "Water levels, etc.") The low-water line from the locks to Lake Huron was drawn parallel to the mean water line, as the total falls at the two stages are practically the same. The slope from below the locks to Hay Lake was deduced from data in the report of the Chief of Engineers, United States Army (1887, p. 2242), which gives the slope of the water surface from the northeast pier to Station G, near the head of Hay Lake, and the slope of the channel from the locks to the angle below Frechett Point, as nearly 0.8 foot. By comparison with the water level at the locks, an elevation of 580.90 feet was deduced for low water of Hay Lake and 582.50 for mean water. As no reliable data could be found for the slope between Hay Lake and Lake Huron, the total fall of 1.30 feet was distributed, 0.70 foot to the channel at the Middle Neebish Rapids and 0.60 foot at Sailors Encampment.

The high-water line was obtained by distributing the increased fall at that stage, to the channel above Hay Lake and below Little Mud Lake.

The dimensions of the locks at the two St. Marys Falls canals were obtained from the reports of the Chief of Engineers, United States Army, and the department of railways and canals of Canada. The elevations of miter sills, platforms, and floors of the American locks were furnished by the Corps of Engineers, United States Army (letters of February 3 and March 23, 1896, from Lieut. J. B. Cavanaugh, Detroit, Mich.), and those of the Canadian lock by the department of railways and canals of Canada (letter of February 10, 1896, from Thomas Monroe, engineer Soulanges Canal, Coteau Landing, Province of Quebec).

The elevations of the water stages above and below the locks, St. Marys Falls Canal, corresponding to 20 and 21 feet in the improved channels, were furnished by the Corps of Engineers, United States Army (letter of February 3, 1896, from Lieut. J. B. Cavanaugh, Detroit, Mich.), and from these data the available depths at mean stage and low water were deduced.

All elevations furnished by the Corps of Engineers, United States Army, and the department of railways and canals of Canada, at or near St. Marys Falls, have been reduced by 0.58 foot, for reasons set forth by Mr. A. E. Kastl (see "Water levels," etc.).

The profile was platted from the soundings on the following charts of the United States lake survey:

	Scale of—
Lake Superior	1:500,000
River Ste. Marie, No. 1	1: 40,000
River Ste. Marie, No. 2	1: 40,000
Straits of Mackinac and the entrance by the Detour Passage to the St. Marys River	1:120,000

LAKE MICHIGAN TO LAKE HURON THROUGH THE STRAITS OF MACKINAC.[1]

(Profile No. 3.)

Profiles on two routes are shown. The full line shows the depth of water on the usual line of navigation between the two lakes. An alternative route with deeper water, and somewhat longer, is shown by a dotted line, on a course north of the Beaver Island group and south of Bois Blanc Island.

The profiles were platted from the following charts of the United States Lake Survey:

	Scale of—
North end of Lake Michigan	1:400,000
Straits of Mackinac	1:120,000

LAKE HURON TO LAKE ERIE THROUGH THE ST. CLAIR RIVER, LAKE ST. CLAIR, AND DETROIT RIVER.[1]

(Profile No. 4.)

This profile shows the available depth of water through the passage between Lake Huron and Lake Erie. The route begins at the foot of Lake Huron, the zero for distance being taken in the channel opposite Fort Gratiot light, and runs in the deep waters through the St. Clair River west of Stag and Woodtick islands and through South Channel to the United States Ship Canal into Lake St. Clair, thence across the lake and down Detroit River, passing west of Fighting Island and east of Bois Blanc Island to near the Detroit River light at the entrance to Lake Erie. The profile is continued through the shallow portion of Lake Erie to deep water beyond Point Pelee.

The water-level elevations of Lake Huron, Lake St. Clair, Detroit River at the foot of Mount Elliott avenue, Detroit, and Lake Erie, were determined by Mr. A. E. Kastl (see "Water levels," etc.).

The fall from Lake Huron to Port Huron has been taken as 16 inches. No exact data respecting this slope have been obtained. Mr. G. Y. Wisner estimated the fall at 1.9 feet in 1.5 miles.[2] Gen. C. B. Comstock, Corps of Engineers, United States Army, states that the fall from the light-house to Black River, in a distance of 2 miles, is about 16 inches.[3] One-half of the slope between Port Huron and Lake St. Clair was assumed to be below the head of the passes in the delta of the St. Clair River.

The low-water slope of the Detroit River was determined from gauge readings for the months of June and July, 1895, as furnished by Lieut.

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[1]Compiled by Mr. Edgar Williams and drawn by Mr. G. A. Lichtenberg.

[2]"The Levels of the Lakes."—Journal of the Association of Engineering Societies, March, 1889.

[3]Letter of General Comstock, dated March 28, 1881, Detroit, Mich. Proceedings of International Deep Waterways Association, Cleveland, September, 1895, page 153.

J. B. Cavanaugh, Corps of Engineers, United States Army,[1] in comparison with Lake Erie for the same period. The mean elevation of Lake Erie for June and July, 1895, was 571.61 feet above mean tide at New York City, or 0.26 foot above standard low water. The standard low-water slope for the Detroit River was found by subtracting 0.26 foot from the gauge readings. The mean gauge readings and the standard low water are given in the following table:

Locality.	Mean gauge reading, June and July, 1895.	Standard low water.
Grosse Point, Lake St. Clair	574.52	574.26
Detroit	574.10	573.84
Trenton	572.86	572.60
Gibralter	571.80	571.54
Lake Erie, Cleveland	571.61	571.35

The grades of the bottoms of the improved channels were obtained as follows:

For each channel, the elevation of the stage of water corresponding to a given depth was furnished by the Corps of Engineers, United States Army.[2] For all the channels except the Lime Kiln Crossing, the stage was given at the channel, and the bottom grade was found by deducting from the stage its corresponding depth. For the Lime Kiln Crossing, the stage of Lake Erie was given, and the elevation was found by adding to the Lake Erie stage the slope between Lake Erie and the Lime Kiln Crossing, as shown by the standard low-water elevations. The grade at the Lime Kiln Crossing was then deduced, as in the case of the channels at other localities.

The elevation at Ballards Reef and at foot of Bois Blanc Island were assumed to be the same as deduced from the observations at Trenton and Gibralter on the American side, and the standard low-water elevation at the Lime Kiln Crossing was estimated in proportion to the distance from these points.

The profile was compiled from the charts of the United States lake survey, as follows:

	Scale of—
South end of Lake Huron and head of St. Clair River	1 : 120,000
St. Clair River	1 : 40,000
Lake St. Clair	1 : 50,000
Detroit River	1 : 40,000
Lake Erie, Coast Charts Nos. 6 and 7	1 : 80,000

The maps and profiles on a reduced scale of the St. Clair and Erie Ship Canal illustrate the proposed channel for shortening the distance on the through route and avoiding the difficulties in the navigation of the Detroit River and the west end of Lake Erie. They were compiled from the following material:

Sketch (with profile) of the Detroit River Passage and the St. Clair and Erie Ship Canal, by D. Farrand Henry, chief engineer.
Chart of Lake St. Clair, by United States Lake Survey.
Chart of lakes Erie and Ontario, by Hydrographic Office, United States Navy.

[1] Letter of February 11, 1896, Detroit, Mich.
[2] Letter of Lieut. J. B. Cavanaugh, February 3, 1896, Detroit, Mich.

LAKE ERIE TO LAKE ONTARIO THROUGH THE NIAGARA RIVER AND PROPOSED SHIP CANAL AND WELLAND CANAL.[1]

(Profile No. 5.)

Three main profiles are delineated, all beginning at a common point of origin in Lake Erie and terminating at a common point in Lake Ontario, as shown on the accompanying sketch of "Niagara Ship Canal Territory," viz: The Welland Canal route as now operated; the natural course of the Niagara River, and the Niagara River in conjunction with the Tonawanda-Lockport-Olcott route for the proposed Niagara ship canal, as favorably recommended in 1889 by Capt. Carl F. Palfrey, Corps of Engineers, United States Army.[2] In addition, subordinate profiles show the alternative routes surveyed in 1867 by Lieut. Col. C. E. Blunt, Corps of Engineers, United States Army.

The water-level elevations of Lake Erie and Lake Ontario were determined by Mr. A. E. Kastl. (See "Water levels," etc.) The approximate elevations of mean water at Black Rock ship lock, head of Grand Island and Tonawanda, were furnished by Capt. Thomas W. Symons, Corps of Engineers, United States Army.[3] The elevation given for Lake Erie was 0.07 foot higher than the level adopted for mean water of Lake Erie. The difference, 0.07 foot, was therefore deducted from the elevations given in determining mean water.

The elevation of mean water at Schlosser was based on the two profiles of Lieut. Col. C. E. Blunt, terminating at Tonawanda and Schlosser, the difference in level being deducted from the elevation adopted at Tonawanda. Estimates were also made of the slope from Black Rock and from Tonawanda to the falls, based on the measured slope and discharge of the Niagara River at Black Rock, and comparisons were made with the contour elevations shown on the charts of the United States Lake Survey and the United States Geological Survey. The elevation of mean water at Lewiston on the chart of Niagara Falls by the United States Lake Survey is given as about 2 feet above Lake Ontario.

The high and low water lines from Black Rock ship lock to Niagara Falls and from Lewiston to Lake Ontario were assumed to have the same slope as the mean water line. The range of variation between mean, low, and high water in the river above the falls, in comparison with Lake Erie, was deduced from the relation between the gauges at Buffalo and Black Rock, established by the discharge observations at Black Rock.[4] The range at Lewiston has been assumed as equal to the range on Lake Ontario.

The elevations of the miter sills of the locks of the Welland Canal at Port Colborne and Port Dalhousie were furnished by Thomas Monro, department of railways and canals of Canada and engineer of the Soulanges Canal.[5]

The elevation of the upper miter sill of the guard lock of the Erie Canal at Black Rock, with respect to canal datum, was furnished by Mr. J. L. Little, division engineer, western division of Erie Canal;[6] and canal datum, with respect to the mean water of Lake Erie, as used by

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[1] Compiled by Mr. Edgar Williams and drawn by Mr. G. A. Lichtenberg.
[2] See Report Chief of Engineers, United States Army.
[3] Letter of February 5, 1896, Buffalo, N. Y.
[4] See Report of Chief of Engineers, United States Army, 1893, page 4368.
[5] Letter of February 10, 1896, Coteau Landing, Province of Quebec.
[6] Letter of February 15, 1896, Rochester, N. Y.

the United States lake survey, was determined for the commission by Mr. George W. Rafter, special engineer, Erie Canal.[1] From these data, the elevation of the miter sill was deduced. The approximate elevations of the water surface of the Erie Canal at Black Rock, Tonawanda, and Lockport were deduced from the above data and the tables of elevations as given in the reports of the State engineer and surveyor of New York.[2]

The profiles and map were compiled from the following charts and documents:

	Scale of —
United States lake survey:	
Lake Erie, coast chart No. 1	1:80,000
Lake Ontario, coast chart No. 5	1:80,000
Niagara Falls	1:20,000
Niagara Falls	1:5,000
Buffalo Harbor and head of Niagara River	1:20,000
United States Geological Survey:	
Buffalo	1:62,500
Niagara Falls and vicinity	1:62,500
Department of railways and canals of Canada:	
Map of part of the Niagara peninsula, showing line of the Welland Canal (including profile) between Lakes Erie and Ontario, 1886	1:36,000

Niagara Ship Canal, with map and profiles; report on surveys for a ship canal to connect Lakes Erie and Ontario, Lieut. Col. Charles E. Blunt, Corps of Engineers, United States Army, 1868.

Profile of ship canal to connect Lakes Erie and Ontario, Eighteen Mile Creek route, revised project, by Capt. Carl F. Palfrey, Corps of Engineers, United States Army, 1889. Scale: Horizontal, 1 inch equals one fourth mile; vertical, 1 inch equals 50 feet.

Report of State engineer and surveyor of New York, 1875, map and profile of the western division of the Erie Canal. Scale, 1 inch equals 2 miles.

LAKE ONTARIO TO LAKE ST. FRANCIS THROUGH THE ST. LAWRENCE RIVER.[3]

(Profile No. 6.)

The profile begins at a point in Lake Ontario opposite Oswego and the same distance from the terminus of profiles No. 5 and Olcott Harbor as the Oswego light-house, which is the origin of profile No. 11. It extends through the main channel of the St. Lawrence and through the Williamsburg and Cornwall canals to the lower end of Lake St. Francis below McKies Point, and to a point at which the profile to Lake Champlain diverges from the St. Lawrence route.

The profile shows the river channel opposite the several canals, and the Canadian channel from Kingston to the foot of Grenadier Island is shown by a broken line. An outline map shows the canal territory between Ogdensburg and St. Regis, covering some 45 miles of difficult river, and over half the length in canal.

The elevations of the standard water lines at the principal points were determined by Mr. A. E. Kastl (see "Water levels," etc.). Below Ogdensburg the profile as furnished by Thomas Monro, member of the Canadian Deep Waterways Commission and engineer of the Soulanges Canal, was substantially adopted, the water lines being modified to conform to the standard elevations as deduced in the water-level investigation.

On the outline map are shown certain lines that indicate possible routes for ship canals. The characteristics of the territory in regard

[1] Letters of March 16 and April 16, 1896, Rochester, N. Y.
[2] Annual Report for 1888, pages 267, 268.
[3] Compiled by Mr. Edgar Williams and drawn by Mr. G. A. Lichtenberg.

to its availability for canal location are set forth in a special report of a reconnoissance made for the Commission by Mr. F. M. Barstow, C. E.

The profile and map were compiled from charts and maps as follows:

United States lake survey:	Scale of—
Lake Ontario, coast chart No. 1	1:80,000
St. Lawrence River, Nos. 1 to 6	1:30,000
St. Lawrence River (detail sheets), Nos. 1 to 8	1:10,000

Hydrographic Office, United States Navy: St. Lawrence River, Cornwall to McKies Point, scale of 2 inches equals 1 nautical mile.

Canadian Deep Waterways Commission: Profile of the St. Lawrence River and canals, 1896 (below Prescott). Scale: Horizontal, 1 inch equals 13,200 feet; vertical, 1 inch equals 50 feet.

Sketch of reconnoissance, by F. M. Barstow. Map, post route, United States.

LAKE ST. FRANCIS TO LAKE CHAMPLAIN AND TO MONTREAL.[1]

(Profile No. 7.)

Beginning at a common point below McKies Point, near the lower end of Lake St. Francis, the same being the terminus of profile No. 6, two main profiles are shown. The southerly profile leads out by Hungry Bay at the southeast angle of the lake and across the Chateaugay Valley into and up the valley of English River and Norton Creek; thence leads southeasterly over a summit, crossing the international boundary some 6 miles west of Rouses Point to the valley of the Great Chazy River at Perrys Mills and Champlain village, and follows thence the Great Chazy River to its mouth in Kings Bay, and to a junction with profile No. 9 in Lake Champlain. The northerly profile is a continuation of the St. Lawrence profile (No. 6), via the Soulanges Canal, Lake St. Louis, and the Lachine Canal to Montreal and to a junction with profile No. 8. An outline map shows the territory contiguous to and north of the boundary and lying within the limits, Lake St. Francis, Lake Champlain, Richelieu River, Montreal, and Lake of the Two Mountains of the Ottawa River, and to which the general name Caughnawaga Triangle may be applied.

The elevations of the water surfaces as shown on the profiles and map were determined by Mr. A. E. Kastl (see "Water levels," etc.), except as herein noted. The distribution of the slope between Lachine and Melocheville was based on hydraulic considerations, as no levels for the intermediate elevations were available. The elevation at the foot of the lock at St. Anne was approximated in the same way, and the elevation of high water at this point and in the Lake of the Two Mountains above was deduced by a comparison of the gauge record at St. Anne for 1876 with low-water stages.

The profile as furnished by Thomas Monro, member of the Canadian Deep Waterways Commission and engineer of the Soulanges Canal, was substantially adopted down to Lake St. Louis, the water lines being modified to conform to the standard elevations as deduced in the water-level investigations. Below Lake St. Louis, the profile of R. Steckel, engineer, published by the department of public works of Canada in report for 1890–91,[2] being based on levels of precision, was adopted, after correction, for elevation of mean tide at New York.

The profile from Lake St. Francis to Lake Champlain is approximate, and represents a probable profile to be found within the band shown on

[1] Compiled by Mr. Edgar Williams and Mr. F. M. Barstow, and drawn by Mr. Hermann Heinze.

[2] Water levels, River St. Lawrence, etc.

the map rather than elevations on a precise location. The portion east of the Chateaugay River is, for the most part, based on well-ascertained elevations, while that west of the river is probably within conditions known to exist in this vicinity.

The map shows the routes of the two profiles, and also the location of the Caughnawaga line, exhibited as part of profile No. 13, and the location of the north end of profile No. 9. The locality of depressions disclosed by the reconnoissance of Mr. Barstow are also shown. The available data regarding elevations are entered on this map. Those determined by Mr. Barstow in the territory between English River and Rouses Point and those along the Canada Atlantic Railway are well ascertained, while those along the other railway lines are from general profiles, and are to be regarded as approximate.[1]

The characteristics of the territory between Lakes St. Francis and Champlain, in regard to its availability for canal location, are set forth in a special report of a reconnoissance made for the Commission by Mr. F. M. Barstow, C. E.

The profiles and maps were compiled from data as follows:

Canadian Deep Waterways Commission: Profile of the St. Lawrence River and Canals, 1896. Scale, horizontal, 1 inch equals 13,200 feet; vertical, 1 inch equals 50 feet.

Hydrographic Office, United States Navy: St. Lawrence River, McKies Point to eastern entrance Beauharnois Canal, and eastern entrance Beauharnois Canal to Montreal. Scale, 2 inches equal 1 nautical mile.

Report with maps and profiles, department of public works of Canada. Water levels, River St. Lawrence between Quebec and Montreal, by R. Steckel, engineer, 1890–91.

Sketch map of the country between Lake St. Francis and Lake Champlain, south of the Canada Atlantic Railway, made for the Commission by F. M. Barstow, C. E., accompanied by a preliminary profile.

Map of the Great Chazy River from Champlain to the lake, from surveys under the direction of Maj. M. B. Adams, Corps of Engineers, United States Army, 1889; the same showing profile of bottom.

Maps of the geological survey of Canada, and by the United States Geological Survey.

Map, international boundary, Report State engineer of New York, 1891. Maps, post route, United States.

Profiles: Detail, of Canada Atlantic Railway; general, of lines of Grand Trunk, Canadian Pacific, Ogdensburg and Lake Champlain, and St. Lawrence and Adirondack.

ST. LAWRENCE RIVER FROM MONTREAL TO DEEP WATER BELOW QUEBEC.[2]

(Profile No. 8.)

This profile shows the available depth in the St. Lawrence River from the foot of the Lachine Canal to deep water, some 60 miles below Quebec. Between Montreal and Quebec it is based on the profile prepared by R. Steckel, engineer, department of public works of Canada.

The standard high and low water lines were obtained by reducing the elevations as given by Mr. Steckel, by his elevation of mean tide at New York City, which is 4.441 feet. The two intermediate flow lines of "High tide during low water," and "Low tide (springs) during freshets," shown on the profile below Pointe du Lac, are approximate. They were obtained from elevations given in Mr. Steckel's "Tables of

[1] The location of the line surveyed under the direction of Thomas Monro, Commissioner, for the Canadian Deep Waterways Commission, has been entered on the map from data received in November, 1896. The profiles were received too late for compilation, but have been published under the auspices of the Canadian Commission.

[2] Compiled by Mr. Edgar Williams and drawn by Mr. G. A. Lichtenberg.

tidal fluctuations for low-water season of 1887, and high-water season of 1888."

The profile was compiled from the following charts and documents:

Report, with maps and profiles, department of public works of Canada. Water Levels, River St. Lawrence between Quebec and Montreal, by R. Steckel, engineer, 1890-91.

Hydrographic Office, United States Navy, Charts of the River St. Lawrence from Quebec to the River Saguenay.

Report, with profile, of the harbor commissioners of Montreal, Canada, John Kennedy, chief engineer, 1882.

THE CHAMPLAIN-HUDSON VALLEY, FROM ST. JOHNS, PROVINCE OF QUEBEC, TO TROY DAM, NEW YORK.[1]

(Profile No. 9.)

This profile shows the line of deepest water and lowest elevation from the entrance of the Chambly Canal, at St. Johns, Province of Quebec, through the River Richelieu, Lake Champlain, the Champlain-Hudson Divide, and the upper Hudson River, to tidewater, at Troy Dam, New York. The location of the route at the northern end is shown on the outline map of profile No. 7, and from Lake Champlain, at Whitehall, to Troy, on map No. IIa. The Mohawk River below Schenectady, which belongs to profile No. II, is also shown.

The water-level elevations for Lake Champlain and the River Richelieu were determined by Mr. Kastl (see "Water levels," etc.). The deduction of the data for the profile of the upper Hudson River involved some perplexities, but it is believed that material errors, if any, are limited to the portion of steep slope above the pool of the Troy Dam, where the effect upon a project would be a minimum.

A route has been suggested from South Bay to Fort Ann in lieu of the one delineated by way of Whitehall. Levels have been run over this line in order to check up the elevations shown on a sketch furnished by the United States Geological Survey. The results indicate greater elevations than shown on map No. IIa, but the data were not sufficient to warrant a profile for an alternative route. The results of this reconnoissance are presented in a special report.

The profile was compiled from the following charts and documents:

Charts of Lake Champlain by the United States Coast and Geodetic Survey.

Map and profile of the Richelieu River, report of R. Steckel, engineer, department of public works of Canada, 1884–85, 1890–91.

Profile of proposed ship canal from Whitehall to Fort Edward and of Hudson River from Fort Edward to Troy Dam. Report of State engineer and surveyor of New York, 1875.

Report and map of survey by Samuel McElroy to State engineer in 1867—Hudson River from Troy to Fort Edward—Senate Doc. No. 37.

Report of Chief of Engineers, United States Army, 1875.

Reports, State engineer and surveyor of New York.

HUDSON RIVER FROM TROY DAM TO ATLANTIC OCEAN.[1]

(Profile No. 10.)

This profile shows the available depth of the tidal portion of the Hudson River, and is extended through New York Bay and across the bar as now improved to deep water of the ocean.

The low and high water lines shown are those of mean low tide and mean high tide as adopted by the Corps of Engineers, United States

[1] Compiled by Mr. E. A. Kastl and drawn by Mr. G. A. Lichtenberg.

Army, and the United States Coast and Geodetic Survey. Freshet high water as determined at Albany, is also shown on the profile. No information could be obtained in regard to the elevation of tide lines between Coxsackie and Dobb's Ferry, and the lines shown are approximate and probably not materially in error. The authority for the elevations used is discussed in another compilation (Elevations for the Great Lakes, etc.).

The profile was compiled from the following charts and documents:

Charts of the Hudson River and New York Bay and Harbor by the United States Coast and Geodetic Survey.

Report of a Board of Engineers on Improvement of Hudson River, above Hudson City, with map and profile, House Ex. Doc. No. 23, Fifty-second Congress, first session, 1891.

Reports of Chief of Engineers, United States Army; United States Coast and Geodetic Survey, State engineer and surveyor of New York.

LAKE ONTARIO TO HUDSON RIVER THROUGH THE OSWEGO-ONEIDA-MOHAWK VALLEY FROM OSWEGO TO TROY DAM.[1]

(Profile No. 11 and map No. 11a.)

That portion of the profile below Schenectady is delineated on the sheet showing profile No. 9, and is to be considered as part of sheet No. II. The map shows also the Champlain-Hudson Valley and the route of profile No. 9, between Troy Dam and Lake Champlain, at Whitehall.

No profile of the direct route between Oswego and Troy has heretofore been made that was adequate for the consideration of a ship canal, all the earlier profiles being of high-level lines through the Mohawk Valley. A fund was placed in the hands of Mr. William Pierson Judson, who was familiar with all existing data in regard to this route, for the purpose of utilizing this information and obtaining other material from private sources and new data in the field, sufficient to show the physical conditions as they actually exist. The result was beyond anticipation, and a profile of a high degree of accuracy has been produced.

Incidentally a map was prepared showing the valley by contours, a most important addition to the profile, and a duplicate of this map has been made in the office of the Commission (No. IIa), Mr. Judson retaining the original.

The special report by Mr. Judson states the source of the data and the manner of compilation so fully that further mention is unnecessary.

GEORGIAN BAY TO LAKE ONTARIO THROUGH LAKE SIMCOE.[2]

(Profile No. 12.)

This profile is drawn for one-half the standard scale and is the first of the series of subordinate profiles designed to illustrate alternative or subordinate routes and existing systems of minor navigation.

The route extends from Nottawasaga Bay to Humber Bay via Lake Simcoe, which has been considered the summit level in all projects, and is popularly known as the Georgian Bay or Hurontario route. The original survey embraced alternative lines for part of the route, one of which crossed the divide to the west of Lake Simcoe, but as none of these have been regarded as presenting more favorable conditions and have not been used in the projects advocated, they are not included in the exhibit.

[1] The profile was compiled by Mr. William Pierson Judson and drawn by Mr. G. A. Lichtenberg. The map was compiled by Mr. Judson and drawn by Mr. Joel Barri, and a copy made for the use of the Commission by Mr. Hermann Heinze.

[2] Compiled by Mr. Edgar Williams and drawn by Mr. William Kramer.

The elevations for the water levels on Lake Huron and Lake Ontario were determined by Mr. A. E. Kastl (see "Water levels," etc.). The elevation of Lake Simcoe above Lake Huron is stated to be 134.07 feet in the General Report of the Public Works of Canada (1867 to 1882, p. 822). By adding this rise of 134.07 feet to the standard low water for Lake Huron an elevation of 713.67 feet was obtained for Lake Simcoe.

The profile was reduced from a profile by Kivas Tully, C. E., dated 1858, and made from original surveys by Mr. Tully, after distributing the correction for the height of Lake Simcoe and a discrepancy in the relative elevation of Lakes Ontario and Huron.

The plans used in the preparation of the profile and map were as follows:

Map showing the route between Lakes Ontario and Huron in the vicinity of Toronto, by Kivas Tully, engineer, March, 1892. Scale, 1 inch equals 2,500 feet.

Profile of the Toronto and Georgian Bay Canal by Kivas Tully, engineer; Toronto, January 15, 1858. Scale, horizontal, 1 inch equals 2,500 feet; vertical, 1 inch equals 100 feet. Map, Province of Ontario, Department of Crown Land, 1895. Scale, 1 inch equals 8 miles.

THE OTTAWA ROUTE FROM GEORGIAN BAY TO RICHELIEU RIVER.[1]

(Profile No. 13.)

This profile extends from Georgian Bay up French River and through Lake Nipissing, and crossing the divide to Trout Lake descends the Mattawan River to the Ottawa River, and through the Ottawa to the St. Lawrence River at Lake St. Louis, thence reaches the Richelieu River at St. Johns by the proposed Caughnawaga canal, joining profile No. 9 at St. Johns and crossing No. 7 in Lake St. Louis. The location of the profile from the Lake of the Two Mountains, via the Caughnawaga route to St. Johns, is shown on the outline map of profile No. 7. The profile is drawn to one-half the standard scale.

The profile was platted from elevations derived from levels in the report of Thomas C. Clarke, C. E., on the proposed Ottawa navigation, and a paper by R. W. Ells, LL. D., and A. E. Barlow, M. A., on the route of the proposed Ottawa Canal. The elevations were derived as follows:

The elevation of standard low water of Lake St. Louis at the head of the Lachine Canal, as determined by Mr. A. E. Kastl (see "Water levels," etc.), is 67.8 feet above mean tide at New York City. From this point to Ottawa Harbor Mr. Clarke's rises through the reaches, which depend on estimate, were corrected in Lake St. Louis, in the Lake of the Two Mountains, and from the head of the Grenville Canal to Ottawa. The rise in Lake St. Louis, from Lachine to St. Anne, was taken at 1.70 feet, as it is generally stated in the Canadian reports at 1 to 3 feet, in place of 0.5 foot, as given by Mr. Clarke. The rise in Lake of the Two Mountains was taken at 0.5 foot in place of 1 foot, and the rise from the Grenville Canal to Ottawa was taken at 1 foot in place of 2.3 feet. With these corrections an elevation of 130.5 feet was obtained for Ottawa Harbor.

From Ottawa to the mouth of the Mattawan River the elevations of Mr. Clarke were corrected so as to agree with the elevations adopted for Ottawa Harbor and the mouth of the Mattawan River, a discrepancy of 0.6 foot in total rise being distributed between the head of Deep River and Mattawa, over which distance the levels are most uncertain.

From the mouth of the Mattawan River to the Petites Dalles of

[1] Compiled by Mr. Edgar Williams and drawn by Mr. C. E. Isbell.

French River, the first rapids above Georgian Bay, the corrected levels of Messrs. Ells and Barlow were used, and for Georgian Bay the standard water levels for Lake Huron.

From Lake St. Louis to the Petites Dalles the bottom of the channel, shown on the profile by a dotted line, is approximate only, and has been drawn from the few approximate depths given in the reports. From the Petites Dalles to deep water in Georgian Bay the bottom was platted from soundings on the charts of the Hydrographic Office, United States Navy. From St. Anne to Caughnawaga, across Lake St. Louis, the bottom was also platted from charts of the Hydrographic Office.

The high-water line was platted from the difference between high and low water, as determined by Mr. Clarke, on the Ottawa and French rivers, and from the elevations determined by Mr. A. E. Kastl for Georgian Bay and Lake St. Louis. (See "Water levels," etc.)

The profile of the proposed Caughnawaga Canal was platted from data in the reports of the Chief of Engineers, United States Army, and the department of public works of Canada.

The profile as platted is substantially the profile of Mr. Clarke corrected for datum. In the paper by Messrs. Ells and Barlow it is stated that "the elevation given for Lake Nipissing is the same as that given by the corrected levels of the Northern Pacific Junction Railway (now part of the Grand Trunk System), and that the elevation at the mouth of the Mattawan River agrees with that deduced from the profiles of the Canadian Pacific Railway." If 10 feet be added to the elevations as given in the table in the original report of Mr. Clarke, they will not differ at any point over 2½ feet from the profile as platted, after making due allowance for the summer water of 1859 on Lake Huron.

In compiling this profile the following charts, maps, and documents were used:

Report on Ottawa Navigation (with profile), by Thomas C. Clarke, C. E., engineer Ottawa survey, Quebec, 1860.

The Physical Features and Geology of the Proposed Ottawa Canal between the St. Lawrence River and Lake Huron, by R. W. Ells, LL. D., and A. E. Barlow, M. A., Ottawa, 1896.

Report on the Montreal, Ottawa, and Georgian Bay Canal, by Marcus Smith, M. Inst., C. E., Ottawa, 1895.

Charts of Georgian Bay, Mouth of French River, and Lake St. Louis, Hydrographic Office, United States Navy.

Report of Chief of Engineers, United States Army, 1875 (p. 587), and General Report of Department of Public Works of Canada, 1867 to 1882.

Profile between Lake Nipissing and Ottawa, compiled by Edwin A. Forward, Ottawa, and received through the Hon. McLeod Stewart, of "The Montreal, Ottawa and Georgian Bay Canal Company."

NOTE.—The profile furnished through Mr. Stewart on November 25, 1896, presumably covers the available data to date, and profile No. 13 has been amended accordingly.—L. E. C.

EARLY CANAL SYSTEMS: ERIE OF NEW YORK, UNITED STATES; RIDEAU—TRENT OF ONTARIO, DOMINION OF CANADA.[1]

(Profile No. 14.)

The first of the two canal systems delineated is the Erie Canal system, comprising the Erie, Oswego, and Champlain canals, by which routes are opened from the Hudson River at Albany to Lake Erie, to Lake Ontario, and to the St. Lawrence River via Lake Champlain and the Richelieu River. These canals have acquired renewed importance

[1] Compiled by Mr. A. E. Kastl and Mr. J. E. Maloney, and drawn by Hermann Heinze. The profile is projected to one-fourth the standard scale.

on account of the enlargement authorized by vote of the people of the State of New York in November, 1895.

The datum for the Erie Canal system is mean low tide at Albany, which is taken as 7,443 feet on the lower miter sill of Lock No. 1.[1] The United States Coast and Geodetic Survey in 1876-77 determined the elevation of miter sill of Lock No. 1 as 6,145 feet below mean tide at New York by levels from the bench mark on the grist mill at Greenbush.[2] Canal datum is, therefore, 7,443 — 6,145 = 1,298 feet above mean tide at New York. The arbitrary, 1.30 feet, was applied to canal elevations in reducing same to mean sea level.

The Erie Canal was carefully leveled in 1876, and the results are published in the reports of the State engineer for the years 1888, 1889, and 1892. In tables are given the length of reaches, bench marks, and elevations of canal bottom from which, after correcting the elevations for sea level, the profile from Albany to Buffalo was platted. The results given in successive reports of the State engineer have been critically compared, and all agree at Black Rock with the elevation as deduced by Mr. Searles in the report of 1876, although there are differences in the assignments of slopes on the reaches with grades between Montezuma and Black Rock.

Canal levels at Buffalo are 0.67 foot higher than by the Lake Survey. (See "Elevations for the Great Lakes," etc.)

The levels for the Oswego Canal are given as far as Van Buren Dam, or to within 7 miles of the terminal lock, in the report of the State engineer for 1891. The miter sill of the terminal lock is as furnished from the office of the division engineer. From these and the tables of lock lifts and reaches, after correcting the elevations for sea level, the profile was platted between Syracuse and Lake Ontario at Oswego.

Canal levels at Oswego are 0.66 foot higher than by the lake survey. (See "Elevations for the Great Lakes," etc.)

The profile of the Champlain Canal was platted from the tables in the report of the State engineer for 1888, after correcting the elevations for sea level. The elevations terminate with the upper miter sill of Lock 21, and the elevation of the lower sill of Lock 23; the entrance lock was furnished by Albert J. Himes, resident engineer, eastern division, Erie Canal.

Canal levels at Whitehall are 0.36 foot higher than by the Coast and Geodetic Survey. (See "Elevations for the Great Lakes," etc.)

The continuation of the profile from Whitehall, N. Y., to the entrance of the Chambly Canal at St. Johns, Province of Quebec, was reduced from profile No. 9.

The profile of the Chambly Canal and of the Richelieu River from St. Johns to the St. Lawrence River was reduced from the profile of R. Steckel, engineer department of public works of Canada (reports, 1885 and 1891), which was referred to the same datum through the international bench mark at Rouses Point.

The second of the two canal systems delineated is the Rideau and Trent Canal system, comprising the Rideau and Trent canals, by which a route is opened from the Ottawa River at Ottawa to Lake Huron at Georgian Bay, via Lake Ontario at Kingston.

This route was projected at an early day, and the Rideau Canal from Ottawa to Kingston opened, which, with short canals at the rapids of the Ottawa River at Grenville and Carillon, the lock at St. Anne and

[1] Report of State Engineer of New York for 1888.
[2] Appendix No. 7, Report for 1887.

the Lachine Canal, furnished a navigation from Montreal to Lake Ontario. Some work was done in connecting the upper lake reaches of the Trent, and this has lately been resumed with a view of opening this section of the route. As both sections are on the same scale of magnitude, they are treated as parts of one system, united through the Bay of Quinte.

The profile of the Rideau Canal was platted from data in the reports of the department of public works of Canada.[1] The elevation of the lower miter sill at Kingston Mills was determined by comparing the depths on the miter sill, as reported by the department of railways and canals, from July, 1893, to June, 1895, with the gauge readings at Oswego. The result is 237.81 feet above mean tide at New York City. It was assumed that the lifts of the locks are from miter sill to miter sill, and that the reaches are level.

The elevation of the lower miter sill of entrance lock at Ottawa Harbor, as thus deduced, is 110.89 feet above mean tide at New York City. The standard depth of the canal is 5 feet. Low water at Ottawa Harbor, with 5 feet on the lower sill, would therefore be 115.89 feet above mean tide at New York. The elevation of the harbor as deduced from the profile of the Ottawa route (profile No. 13) is 130.50 feet, or 14.61 feet higher. Various comparisons have been made to determine the source of this discrepancy, and letters were sent to Mr. Thomas C. Keefer, member of the Canadian Deep Waterways Commission, and to Mr. R. Steckel, engineer department of public works, but no sufficient explanation has been found.

The profile from Kingston to the mouth of the Trent River, through the Bay of Quinte, was platted from the chart of the Hydrographic Office, United States Navy.

The profile of the Trent Canal was platted from data in the reports of the department of public works of Canada.[2]

These data were brought down to date from the latest reports of the department of railways and canals (1895). Those portions of the route upon which works are still undetermined are shown by a broken line.

The plane of reference to which the elevations were referred in the above reports is ordinary low water of Lake Ontario, which is taken at 12.5 feet above the bottom of the Murray Canal, which unites the western end of the Bay of Quinte with Lake Ontario, and is the same as the zero of the Toronto gauge. This elevation was determined as 245.40 feet above mean tide at New York City (see "Water levels," etc.) and this quantity was used in reducing the profile to sea level.

The elevation of Georgian Bay on this profile is 582.15 feet, or 2.55 feet above standard low water and 1.72 feet above ordinary low water (assumed equal to that for Lake Ontario). Corrected to the Lake Huron level, the elevation of Lake Simcoe is the same as on profile No. 12.

INTER LAKE ROUTES; SUPERIOR AND GREEN BAY CANAL; GRAND-SAGINAW ROUTE; MICHIGAN AND ERIE ROUTE.

(Profile No. 15. Not delineated.)

The data procured in regard to these routes were insufficient to justify a profile. It was anticipated that parties especially interested would complete the information.

[1] Report of 1867, pages 55–61, and Appendix No. 7, pages 59–67; also, General Report, 1867–1882, pages 816, 817.

[2] Report of 1867, pages 70–79, and Appendix Nos. 14 and 15, pages 122–129; also, General Report, 1867–1882, pages 818–823.

The Superior and Green Bay Canal was advocated some years since, but the surveys supposed to have been made have not been found. The route is from Au Train Bay up Au Train River and down Whitefish River to Little Bay de Noque, the northerly arm of Green Bay on which Escanaba is situated. This is recognized as the lowest pass between Lakes Superior and Michigan, and is also the lowest in the watershed of Lake Superior west of Sault Ste. Marie.

Mr. Lucius L. Hubbard, State geologist of Michigan, writes:

The only information we have in this office is contained in Vol. I, Michigan Geological Reports, Part III, page 75, and is as follows: "Also Mud Lake and the series of connected lakes and marshes from which Au Train River makes its exit on the north side and Whitefish River on the south side have their basins eroded through the drift down to the older rock beds. The level of the lake lies from 60 to 70 feet below the top of the plateau. * * * This watershed lies, as has been mentioned before, in a valley eroded into the drift, to the depth of perhaps 70 feet, but the sole of this valley is at least 300 feet above Lake Superior."

The agent of the Munising Railway and of the land company at Munising undertook to furnish further information, but without results.

The Grand-Saginaw route is through the great depression that crosses Michigan from Grand Haven via the Grand River and through a summit swamp and Saginaw River to Saginaw Bay at Bay City. The route appears to be available for a navigation of considerable capacity.

A survey of Grand River has been made from Lake Michigan to Grand Rapids, and of Saginaw River to Saginaw. Some intermediate points were obtained from railway profiles. Mr. George A. Nettleton, chief engineer Ann Arbor Railroad, writes: "The general elevation of the swamp between Ashley and Bannister is from 93 to 95 feet above the water level of Lake Michigan." Low water at Grand Rapids, as determined by United States engineers, is 7 feet above standard low water of Lake Michigan.

A small contour map by Prof. Alexander Winchell, late State geologist of Michigan, shows that the drainage of a large section of the State is higher than the valley and may be made tributary to the summit level. The following extract from "Kendall's Michigan, its geography, history, and resources, and civil government," was furnished by the secretary of the Grand Rapids Board of Trade:

Viewing the peninsula as a whole, we discover, first of all, a remarkable depression stretching obliquely across from the head of Saginaw Bay, up the valley of the Saginaw and Bad rivers, and down the Maple and Grand rivers to Lake Michigan. This depression obtains nowhere an elevation greater than 72 feet above Lake Michigan. This elevation is in the interval of 3 miles separating the waters flowing in opposite directions. The spot was chosen in 1857 for a canal connecting Saginaw Bay with Lake Michigan.

The Michigan and Lake Erie route is from the head of Lake Michigan to the Wabash Valley, between La Fayette and Logansport, and thence by the Wabash, the Fort Wayne summit, and the Maumee Valley to Lake Erie at Toledo.

Surveys from Lake Michigan to the Wabash River were made in 1831 by Capt. Howard Stansbury, and these were reviewed and additional examinations made by Maj. G. L. Gillespie in 1875.[1] From these and from railway elevations it appears that there are two ridges and an intermediate valley to cross on a probable location, the northern ridge some 167 feet, the Kankakee Valley some 70 feet, and the southern ridge about 128 feet above the level of Lake Michigan. The Wabash at Lafayette is 75 feet below Lake Michigan, and at Logansport at the level of the lake.

[1] Report Chief of Engineers, United States Army, 1876.

From Lafayette to Toledo the Wabash and Erie Canal and the Miami and Erie Canal furnished a water route at one time, and the Miami is still in operation. This route was examined by Maj. John M. Wilson in 1881 and a report with profile and estimates submitted[1] for a canal on the scale of the present Erie Canal. The summit level at Fort Wayne was fixed at 183 feet above Lake Michigan.

These early surveys were all for high-level lines and small prisms. Some additional field work is required to produce a profile along the lowest line. The route appears to be available for a waterway of moderate capacity.

Mr. William T. Harris, of Defiance, Ohio, has promoted a route leading north of Fort Wayne and through a series of depressions and lakes at the head waters of the Eel, Tippecanoe, and Elkhart rivers to the valley of St. Joseph River, via Elkhart and South Bend, and thence to Michigan City. The summit level proposed for this route is about 284 feet above Lake Michigan.

WESTERN NEW YORK.

(No profile.)

In 1885 Mr. Elnathan Sweet, formerly State engineer, proposed the radical enlargement of the artificial waterway between Lake Erie and the Hudson River.[2] The route suggested was substantially along the present route of the Erie Canal with a detour to the higher ground south between Lock 57, east of Newark, and the end of the Rome level at Syracuse, so as to feed the canal continuously from Lake Erie. The possibility of a lower level at Rome and a more favorable location for the high level east of Newark was suggested. East of Rome it was proposed to canalize the Mohawk River.

A moderate enlargement of the Erie Canal with the high-level location has also been suggested as a feeder to the Rome summit for the proposed ship route from Lake Ontario at Oswego.

To ascertain what positive information might be available for these projects, a letter was addressed to Mr. Sweet, to which he replied in part as follows, under date of March 3, 1896:

> My suggestions were based on the Erie Canal profile and my intimate knowledge of the country along its route, and I explicitly disclaimed the possession of definite engineering data in the paper to which you refer, which was in fact a plea for thorough and comprehensive surveys to determine the elements of the undertaking. Every effort to secure such surveys through State or national legislation has thus far proved abortive, and without the fact to be developed by them, nothing can be more frivolous or futile than the discussion of the engineering side of this question.

The small profile of the Erie Canal (No. 14) shows the sag through the lake country of New York between Newark and Syracuse, which was to be avoided by a high-level line on the slopes south of the present location. It was expected to test this proposition by a careful instrumental reconnoissance and an approximate location, had the available funds permitted.

In the original location of the Erie Canal west from Irondequoit, Mr. Geddes considered a route south of the mountain ridge through the valley drained by Black Creek and Oak Orchard and Tonawanda creeks. It was thought that this proposition might appear less for-

[1] Report Chief of Engineers, United States Army, 1881.
[2] Transactions, American Society of Civil Engineers, 1885.

midable to modern resources in canal building and avoid side hill location across drainage lines. Accordingly, elevations were obtained at the Tonawanda feeder dam and the profile of the West Shore Railway from Tonawanda crossing to the Genesee River, which traverses the route in part. A profile was also obtained of the line of the Lehigh Valley Railway from the Genesee River to Seneca Lake.

The results were inconclusive as to the possibility of a route south of the present location between Tonawanda and Cayuga Lake, but the indications were very doubtful. If this conclusion is found correct by future examinations, the only material modification in route is along the lines suggested by Mr. Sweet, unless the Rome summit is radically modified.

NEW YORK AND PENNSYLVANIA.

(No profile.)

A possible water route of moderate capacity is from Lake Ontario to Chesapeake Bay, starting at Sodus Bay and by either Cayuga or Seneca Lake, thence crossing the southern divide into the valley of the Susquehanna and through the same to its mouth.

The Chemung Canal at one time extended from the head of Seneca Lake over the summit to the Chemung River at Elmira, or to within less than 10 miles of the North Branch Canal of Pennsylvania at the State line. These early canals of very small prism were abandoned before a through route had been opened for the mineral traffic of eastern Pennsylvania.

No sufficient data for a profile of the route was obtained.

CONCLUSION.

The foregoing exhibit presents the available routes for uniting the several members of the lake system with each other and for connecting the same with the eastern seaboard. The available passes through the heights of lands are really few in number, and these are now quite well understood in their relations to the basin of the lakes and to the valleys leading out therefrom.

In order to cover more fully the subject of possible routes from the lake basin, the elevations of the characteristic passes that cross the watershed of the lakes and of their valley extensions have been entered on the basin map (Basin of the Great Lakes, etc.), and these may be compared with the routes along which profiles have been developed or to which reference is made in the foregoing notes.

APPENDIX.

DISTANCES—LAKE-SEABOARD ROUTES.

The following schedule gives the principal distances in statute miles on the routes as shown on General Route Map No. 1a, and as used in compiling the distance diagram on profile No. 1:

Chicago (Madison street) to Mackinaw ..... 2 + 347.5 = 349.5
Mackinaw to Lake Huron Junction 83.5
Chicago to Lake Huron Junction ..... 349.5 + 83.5 = 433
Duluth-Superior to Sault Ste. Marie 397.5
Sault Ste. Marie to Lake Huron Junction 103
Duluth-Superior to Lake Huron Junction ..... 397.5 + 103 = 500.5

Route.	Intermediate.	Total.
	Miles.	*Miles.*
Lake Huron Junction via Lake Erie route:		
Fort Gratiot Light		170.5
Detroit	64.5	235
Detroit River Light	25	260
Origin, Niagara Profile (No. 5)	209	469
Buffalo	27	496
Tonawanda	11	507
Olcott, Niagara Canal route	26	533
Lake Ontario Junction	36	569
Origin, Niagara Profile (No. 5)		469
Port Colborne Light (Welland Canal)	12.3	481.3
Port Dalhousie Light (Welland Canal)	28.4	509.7
Lake Ontario Junction, Welland Canal route	64.6	574.3
Lake Huron Junction via Georgian Bay route:		
Georgian Bay Junction (Ottawa route)		87
Origin, Georgian Bay Profile No. 12 (1 mile off shore)	83	170
Lake Ontario (near Toronto)	100	270
Lake Ontario Junction	70.5	340.5
Lake Ontario Junction via Mohawk route:		
Oswego Light (origin of profile No. 11)		79
Troy Junction (State dam)	177	256
New York, Battery	154	410
Atlantic Ocean, Sandy Hook Light Vessel	28	438
Lake Ontario Junction via St. Lawrence-Champlain route:		
Cape Vincent		100.5
Ogdensburg	60	160.5
Lake St. Francis Junction (origin No. 7)	76	236.5
Lake Champlain Junction (near Rouses Point)	55	291.5
Whitehall	103	394.5
Troy Junction (State dam)	64	458.5
New York, Battery	154	612.5
Atlantic Ocean, Sandy Hook Light Vessel	28	640.5
Lake Ontario Junction via St. Lawrence route:		
Lake St. Francis Junction		236.5
Lake St. Louis Junction (Ottawa route)	31	267.5
Montreal (mouth of canal)	12	279.5
Quebec (Louise embankment)	161	440.5
Saguenay River	116	556.5
Gulf of St. Lawrence, Point de Monts	139.5	696
Lake Huron Junction via Ottawa route:		
Georgian Bay Junction (Georgian Bay route)		87
French River, mouth (origin No. 13)	45.5	132.5
Mattawa (Ottawa River)	123.5	256
Ottawa	191	447
Lake St. Louis Junction (St. Lawrence route)	105	552
St. Johns, Caughnawaga Canal	34.5	586.5
Lake Champlain Junction	30	616.5

For New York and St. Lawrence distances, see preceding tabulation.

SUMMARY.

Chicago to American seaboard. (Duluth and Superior, add 67.5 miles.)	Sea level, Troy.	New York City.	Atlantic Ocean.
	Miles.	*Miles.*	*Miles.*
Lake Erie and Mohawk route	1,258	1,412	1,440
Lake Erie and St. Lawrence-Champlain route	1,460.5	1,614.5	1,642.5
Georgian Bay and Mohawk route	1,029.5	1,183.5	1,211.5
Georgian Bay and St. Lawrence-Champlain route	1,232	1,386	1,414
Ottawa and Champlain route	1,216.5	1,370.5	1,398.5

Chicago to Canadian seaboard. (Duluth and Superior, add 67.5 miles.)	Sea level, Montreal.	Deep water, Saguenay River.	Gulf of St. Lawrence.
	Miles.	*Miles.*	*Miles.*
Lake Erie and St. Lawrence route	1,281.5	1,558.5	1,698
Georgian Bay and St. Lawrence route	1,053	1,330	1,469.5
Ottawa and St. Lawrence route	997	1,274	1,413.5

SPECIAL REPORT ON OSWEGO–ONEIDA–MOHAWK ROUTE.

OSWEGO, N. Y., *May 20, 1896.*

GENTLEMEN: The accompanying map of the Oswego-Oneida-Mohawk Valley, and also the profile of the most favorable line through it for a ship canal from Lake Ontario at Oswego, N. Y., to tide water in the Hudson River at Troy, N. Y., have been prepared by me in compliance with your request of February 5, 1896, for "cooperation with the Commission in determining and obtaining essential information" regarding this route.

The purpose of these examinations and surveys, and of this compilation of the results of the various former surveys of portions of the route, has been to exhibit the existing natural features of these connecting river valleys through which the Great Lakes formerly found an outlet to the sea.

HISTORY.

From 1750 this has been recognized as the natural line for a canal from the lakes to tide water. During the Revolutionary war General Washington examined parts of it, and about 1790 was himself the head of a company formed for canal construction from Lake Ontario, by way of the Oswego and Oneida rivers, Oneida Lake, and Wood Creek, to the Mohawk River at Rome.

Beginning in 1796, with a capacity for boats of 15 tons each, three successive systems of navigation have been constructed on this line, each larger than the preceding; but all have been too small to utilize the full size of the rivers or to receive or control their floods, and the canals have, therefore, been built along the banks of the Mohawk and the Oswego and above their flood line, crossing the Mohawk's tributaries by aqueducts. The different surveys for greater proposed enlargements (to 9, 10, and 14 feet depth, respectively) have also been along the same high-level lines, and thus it results that no definite knowledge has heretofore been obtained as to the real adaptability of this valley, or series of valleys, to the construction of a ship canal (or chain of canalized rivers), which must be made wide and deep enough not only to pass through its locks the great steamers of the lakes and of the ocean, but also to receive and control within its banks and over its movable dam crests the yearly floods and ice of the rivers and of their tributaries. It has, therefore, been repeatedly and justly said that the data did not exist for making estimates for such a ship canal, and that its details could not be discussed without them.

DATA NOW SUPPLIED.

It is considered that the map and profile now presented will supply all that is needed for any preliminary comparison and discussion, and also for making approximate estimates of cost of any desired canal construction upon the line which is here selected and indicated, and which is adaptable to a ship canal of the largest size.

DESCRIPTION OF LINE.

This line follows the Oswego River channel from Lake Ontario for 21 miles southward to a point near its junction with the Oneida and Seneca rivers, where the water surface is 114 feet above extreme low-water level of Lake Ontario. Here the line cuts across the intervening ridge to the Oneida River (which is here from 25 to 40 feet in depth) and takes the most direct line eastward to Oneida Lake, cutting off the great bends in the Oneida River and reducing its length from 18 miles to 9 miles.

ONEIDA LAKE.

A special survey was made of Oneida Lake which forms an important feature of the route.

The United States Geological Survey charts show only that its length is 21 miles, its average width 4.1 miles, and its mean-level elevation above tide at New York 370 feet.

The depths are found to be 9½ feet at the outlet at Brewerton, gradually increasing to 20 feet at about 3 miles eastward, and 25 to 49 feet for the remaining 18 miles to the eastern end of the lake. Here the shore, in the vicinity of the common outlet of Fish Creek and Wood Creek, is of fine sand and has a slope of 1 per cent, reaching a depth of 20 feet at 2,000 feet offshore.

This was the original entrance into Oneida Lake of the branch of the 3½ feet Erie Canal as surveyed in 1808 and built in 1832–1836; but the shifting sands made it so difficult to maintain the unprotected entrance that this branch was abandoned when the canal was enlarged to 7 feet in 1863–64.

A permanent entrance would now be assured by sand-tight jetties carried out to 20 feet depth, through which the valley of Wood Creek may be reached and thence followed by the most direct line, cutting off all its crooks and bends, to the head of the Mohawk Valley at Rome through the dividing summit, 444 feet above tidewater and just 200 feet above extreme low-water level of Lake Ontario. Here the two historic streams are within 1,600 yards of each other, and the line of the portage of colonial times, over which all the commerce of the West then passed, is now the main street of the town.

BRIDGES.

The location of line at Rome is such as to avoid crossing the four-track New York Central Railroad. Elsewhere the number of drawbridges which would be called for is at a minimum. Those which now exist and which would be needed to cross the route between Oswego and Troy are as follows:

Existing railroad bridges:	
Four-track (one near Utica and one at Schenectady)	2
Two-track (one at Oswego and one at West Troy)	2
One-track	4

Additional railroad bridges:	
One-track	3
In all	11
Existing highway bridges	41
Additional highway bridges	14
In all	55

MATERIAL.

At Little Falls (100 miles from Lake Ontario by the line selected) the first rock, in the Mohawk Valley, appears and the first marked fall of the Mohawk River occurs, being about 50 feet within 2 miles. The river surface just above the falls is about on a level with the surface of Oneida Lake, 50 miles distant, and this has often suggested the advantage of cutting through the intervening ridge down to the Oneida Lake level. For the consideration of this enormous excavation there has been needed a more definite knowledge of the material forming the dividing ridge. This has now been obtained from the record of a number of deep-well borings which have been made at various places between Rome and Little Falls, and which give assurance that only glacial drift exists above a line 330 feet above tide water, or 40 feet below the surface of Oneida Lake. The same character of material was found to form the bottom of Oneida Lake, most of which has a depth of 40 feet or more. To determine this, every sounding was made with a specimen dredge, which brought up 20 cubic inches of clay, gravel, sand, or mud at each of the 100 or more soundings which were distributed over its whole area.

MOHAWK VALLEY.

From Rome eastward the line follows the general course of the Mohawk River, which from here to Little Falls meanders from side to side of the Mohawk Flats, which vary from half a mile to 1 mile in width and are bounded by the hills on either hand.

From Little Falls eastward the Mohawk is closely bounded by rocky hills on either side and the line more nearly follows the actual river bed as far as the Falls of Cohoes, where the Mohawk descends into the Hudson. Here the present line of the Erie Canal is taken to accomplish the descent of 146 feet to the Hudson just above the State dam at Troy, where tide water is reached, 177 miles from Lake Ontario, and where the Hudson River is available thence for 154 miles to the Battery in New York Harbor.

WATER SUPPLY.

This examination has not included the all-important feature of water supply for the summit level at Rome, which is recognized to be the only doubtful feature of this otherwise obviously desirable route. The writer has however satisfied himself that the necessary water for the operation of any ship canal on this line can be supplied in three different and practicable ways: first, by reducing the demand by the use of balanced caisson locks at each end of the summit level (the lower levels being amply supplied by inflowing streams) and by utilizing, for purposes of navigation only, the whole of the present stored supply of the summit level of the Erie Canal; second, by increased storage in the lakes and valleys of the Adirondacks, supplemented, if need be, by a moderate-sized high-level feeder bringing Lake Erie water for 70

miles from the present Erie Canal at Macedon around on the hillsides lying south of the present lower levels of the Erie Canal, and thus reaching the Rome level; or, lastly, by cutting through the Rome summit down to the level of Oneida Lake and using its storage capacity. The last appears to be the least desirable, but either is feasible. Which of them will prove to be the most economical and effective can be determined when the more definite estimates for final construction are needed.

AUTHORITIES.

In the preparation of this map and profile full use has been made of the records of the State engineer's office at Albany and of the United States engineer office at Oswego, under both of which offices surveys for projected canal enlargement have formerly been made. The published maps of the United States Geological Survey have also been utilized from Phœnix to Utica and from Fonda to the Hudson. The details of the Rome summit were obtained from a recent and accurate contour map made in 1895 by the Stanwix Engineering Company. The profile of the Oswego River is based in part upon a very full and careful profile made in 1820 by Civil Engineer Bates, while the river was in its natural state and before the building of the first canal in 1825–1828. Most of its bed being of rock, the main changes have been due to the dams, and these changes were obtained from an equally complete profile made in 1896 by Mr. Henry C. Allen, C. E., who is mentioned later. The part showing the valley of the upper Hudson from Lake Champlain to Troy has been prepared from the records of all the numerous surveys which have been made of it—largely from one made in 1853 by William A. Perkins, resident engineer New York State canals, checked by the profile prepared by Mr. Isham Randolph, C. E., of Chicago, and issued in January, 1896, by the Western Society of Civil Engineers. The remaining parts were made up from the most reliable sources available and from characteristic cross sections of the valleys made for this purpose with stadia and hand level at one hundred or more points between Oswego and Troy. Particular mention is made of Mr. Albert J. Himes, associate member of the American Society of Civil Engineers, of Albany, and Mr. Henry C. Allen, associate member of the American Society of Civil Engineers, of Syracuse, each of whom has supplied most valuable material in addition to that obtained by the writer.

ICE RECORDS.

The ice records of Oneida Lake, which also accompany this report, show that the lake is free from ice for an average of 253 days[1] per year. The average dates during the past fifty years on which Oneida Lake has closed in winter and opened in spring are December 17 and April 6, while the rivers usually close later and open earlier.

OBJECT OF THIS REPORT.

It is not the present purpose to offer any general arguments upon the need for a great canal from the lakes to tide water, nor to make estimates for any specific canal construction along this particular

[1] The above is increased to 255 days by omitting one of the terminal days and the odd day in February.—L. E. C.

route; the intention is merely to show the existing conditions of essential features for use in making future estimates for the Oswego-Oneida-Mohawk Valley route from Lake Ontario to the Hudson River.

Respectfully submitted.

WILLIAM PIERSON JUDSON.

The UNITED STATES DEEP WATERWAYS COMMISSION.

ST. LAWRENCE–CHAMPLAIN ROUTE.

SPECIAL REPORT ON PRELIMINARY RECONNOISSANCES MADE BY F. M. BARSTOW, C. E., AND THOMAS A. PATERSON, C. E.

I. St. Lawrence Rapids, Ogdensburg to St. Regis.
II. St. Francis and Champlain Canal route.
III. South Bay route, Champlain-Hudson Divide.

INTRODUCTION.

The object of these reconnoissances was to determine the availability for ship-canal location of certain territory, which has not heretofore been utilized or examined in detail for this purpose, on the route from Lake Ontario to tide water of the Hudson River by way of the St. Lawrence River and Lake Champlain.

In the development of this route, three localities require works of magnitude.

(1) Some 45 miles of the St. Lawrence River, descending some 91.3 feet by a series of rapids from the level of Lake Ontario at Ogdensburg to the level of Lake St. Francis at St. Regis. This series of rapids is overcome on the Canadian shore by the Williamsburg and Cornwall canals, consisting of four distinct canals—viz, the Galops, 7.60 miles; the Rapide Plat, 3.70 miles; the Farrans Point, 0.75 mile; and the Cornwall, 11.50 miles—aggregating 23.55 miles, and intermediate reaches of water, aggregating 19 miles, a total of 42.55 miles. The conditions are somewhat rugged for the development of canals of larger capacity along the Canadian shore, and it was determined to examine the American side for a more favorable location.

(2) Some 45 miles lying north of the outlying spurs of the Adirondacks, between the southeast angle of Lake St. Francis and the level of Lake Champlain in the Great Chazy River, southwest of Rouse Point, and descending some 58.5 feet. Routes had been surveyed from Lake St. Louis to the Richelieu River at St. Johns, and also from Lake St. Francis to the same point, and it was desired to develop the extreme southern and the shortest possible line across the base of the Caughnawaga triangle, bounded on the sides by the St. Lawrence and Richelieu rivers.

(3) Some 35 miles of the Champlain-Hudson divide between the head of Lake Champlain and the Hudson River at Saratoga Dam, at which the river drops below the Champlain level. For that portion of the divide north of Fort Ann an alternative line to South Bay, a westerly arm of Lake Champlain, has been suggested, the proposed location being somewhat shorter and more direct than the line by way of Wood Creek to Whitehall.

The funds available were entirely inadequate for making any proper surveys, and so the examinations were limited to rapid reconnoissances,

which it was anticipated would develop significant features, justify surveys, and determine their proper scope.

The following notes and reports present the results obtained on the three divisions in their natural order:

I. ST. LAWRENCE RAPIDS, OGDENSBURG TO ST. REGIS.

The reconnoissance on the south shore or American side of the St. Lawrence between Ogdensburg and St. Regis was made by Mr. F. M. Barstow, C. E., in the latter part of May. He was instructed to "take a critical view of the territory in the quickest and most convenient manner, and form a judgment as to how favorable it may be as compared to the Canadian shore, having in view some probable solution for each rapid that may require a separate canal. In this connection the utility of islands and by-channels claim consideration, and also the possibility of crossing over to the valley of Grass River from the head of the Long Sault, or of actually canalizing the American channel itself."

Mr. Barstow's report is given below. The information on his sketch map is compiled with other material on the outline map submitted as part of profile No. 6, to which reference is made in the report. The detail charts of the United States Lake Survey are elaborate in respect to soundings and the immediate shores. The information regarding elevations is meager and is presented on profile No. 6.

It appears that the most difficult problem is presented at and below the Galops Rapids, and that elaborate surveys will be required to properly develop the utility of the south shore and the back country for canal location.

BURLINGTON, VT., *May 26, 1896.*

SIR: I have the honor to submit the following report on a preliminary reconnaissance made on the south bank of the St. Lawrence River, between Ogdensburg and St. Regis, to determine the feasibility of canal location there, as compared with the now existing works on the Canadian side, as instructed by your letter of May 15. The time allowed for the work was so short and the difficulties of the country so great that I am not able to present any location, but can only describe the general lay of the country and verify the maps already in existence.

Over the entire distance from Ogdensburg to St. Regis the banks of the St. Lawrence River are stable and abrupt, rising from 30 to 40 and 60 feet above the water. This is also shown by contour lines on printed charts made from surveys of the northern and northwestern lakes by Maj. C. B. Comstock, Corps of Engineers, United States Army, in 1871, St. Lawrence River sheets Nos. 1 to 8, scale 1:10,000.

The material is clay, bowlders, and sand. The only solid rock showing on the surface is in the immediate vicinity of St. Regis, although of course a great portion of the bottom of the St. Lawrence River is rock.

The Galops Rapids are the first rapids below Ogdensburg and are now passed by the Galops Canal, on the Canadian side, some 7¼ miles long.

To pass them on the American side two courses would seem to be open—either to cut the canal through the banks, which are some 25 feet high near the river, or to utilize a continuous stretch of islands over the first 3 miles by connecting them with embankments and building a dam from Sheldon Island to the shore. This would give a channel some one-fourth mile wide and would not require much deepening to give 24 feet of water. From Sheldon Island I can see no way except to build a canal the remaining 4 miles to slack water, entirely in excavation with banks about 20 feet above the water. I found no depression or any indication of a depression through the country back from the river.

The next rapids are now passed by the Morrisburg Canal, about 4 miles long. To pass them on the American side Ogdens Island and a chain of smaller islands might be utilized to canalize the American channel, or a canal would have to be cut in excavation with banks some 30 feet above the water.

Farrans Point Canal is short, being three-quarters of a mile long and located near the head of Croils Island. The swift water on the American side, however, appears to be nearly 2 miles farther downstream, near the foot of the same island, and the problem here is precisely the same as at the rapids above.

The next and last rapids before entering Lake St. Francis are the Long Sault Rapids now passed by the Cornwall Canal, 11¼ miles long, with fall of some 47 feet.

The location of the islands for the first 7 miles is such that it would seem as if the American channel could be canalized if it were not for the great volume and very swift water that passes between Long Sault Island and Barnharts Island. Then cutting through banks averaging 30 feet high, and in places from 40 to 80 feet high, is 5 miles to slack water.

There is also another way of passing the Long Sault Rapids shown on the accompanying sketch map.[1] There are two rivers—the Grass River, about 2 miles back in the country, and the Racket River, 1 mile still farther back, that flow through great valleys parallel to the St. Lawrence—which might be utilized. The Grass River, at a point opposite the head of the Long Sault Rapids, is 2 miles distant and about 40 feet lower than the St. Lawrence River, but separated from it by a ridge which, in places, must be 100 feet higher than the St. Lawrence. The mouth of Grass River is in swift water of the St. Lawrence. The Racket River is about the same elevation as Grass River, and is 1 mile farther south, and separated from Grass River by a high ridge, but its mouth is in slack water of the St. Lawrence. Both these rivers flow between high, stable banks and are substantially slack water from Massena to the St. Lawrence.

If the waters of the St. Lawrence can be carried from the head of the Long Sault Rapids 3 miles across into the Racket River, the remaining 9 miles of canal is built by simply damming the mouth of Racket River.

The water of the St. Lawrence River can be carried into these rivers either by cutting through the two high ridges mentioned a distance of 3 miles, or, by going back up the St. Lawrence about 5 miles, there is a depression in the country from the St. Lawrence to the Racket River, as indicated on sketch map,[2] which, however, lengthens the canal route some 7 miles, but greatly lessens the depth of excavation.

I have simply tried to give you some information of the country between Ogdensburg and St. Regis, without any opinion as to ship canal limitations or what is the best route or course to pursue. I am fully convinced that after accurate surveys are made of this country, and full and correct data are obtained, that problems will be presented that will cause discussion among the best engineering talent of the country, and I would consider it presumption on my part to assume to say now whether it would be more feasible to build new canals on the American side or enlarge the works now in operation in Canada.

Very respectfully submitted.

F. M. BARSTOW.

Mr. LYMAN E. COOLEY, C. E.,
Engineer United States Deep Waterways Commission.

II. ST. FRANCIS AND CHAMPLAIN CANAL ROUTE.

The reconnoissance between Lake St. Francis and Lake Champlain south of the Canada Atlantic Railway was made by Mr. F. M. Barstow, C. E., in the month of April, 1896. The weather conditions during a portion of the period were very bad, owing to melting snow, rains, and heavy floods, but the results were needed at an early day, in order to give direction to other work. The information secured was more than had been anticipated.

The trend of the streams in this region seemed to suggest a possible location, which was reenforced by an examination of available maps and profiles and by the opinions of those familiar with railway surveys. It was determined to make a sufficient reconnoissance to test the matter, with the result of extending the examination until the territory in question was developed as far as seemed advisable without actual surveys.

Mr. Barstow was instructed to confine his operations to the route from Lake St. Francis via the Chateaugay and English rivers and Norton Creek valleys to a terminus in the vicinity of Lacolle, or south of Rouse Point, as the territory farther north, from Lake St. Francis and Lake St. Louis to the Richelieu River in the vicinity of St. Johns,

[1] See Outline map, profile No. 6.

[2] See profile No. 6.

had been covered in old surveys, and had been further examined by Mr. Thomas Monro for the Canadian Deep Waterways Commission.

Mr. Barstow's report is given below, along with a supplemental report in response to further instructions regarding the territory between Lake St. Francis and the Chateaugay River. The information given in his sketch map and profile has been compiled, along with all other information that could be secured, in the outline map and profile designated as profile No. 7, and to this reference is made in connection with the report. The data incorporated in profile No. 7 are set forth in "Notes on profiles," etc.

Mr. Barstow's work has developed a feasible route, and a full survey is amply justified. The information available is insufficient for a specific project or to determine relative availabilty, though the shortening of distance in restricted navigation invites favorable consideration.

BURLINGTON, VT., *April 28, 1896.*

SIR: I have the honor to make the following report on a preliminary reconnaissance of the St. Lawrence-Champlain route, to ascertain if any final surveys were feasible, made under your direction and in accordance with your letter of instructions of March 28, 1896.

From Valleyfield southwesterly for 5 miles, and as much farther as one could see, the shores of Lake St. Francis are low, being only from 3 to 5 feet higher than the present level of the lake; and permanent embankment walls, for this distance at least, would be required if the level of the lake was raised.

From near Lake St. Francis to the junction of English River and Norton Creek, along the line of the Canada Atlantic Railway, as is shown by the accompanying profile, the land is lower than the level of Lake St. Francis. This country being so generally level from west to east and having a gentle slope up toward the south, very little time was spent upon it.

Two lines for survey are indicated on the accompanying sketch map,[1] one on what I judge to be the Lake St. Francis level, from 1 to 3 miles south of the Canada Atlantic Railway to the English River, then up this river to the mouth of Norton Creek at Aubrey. The other line leaves Lake St. Francis about 3 miles farther south, going near St. Barbe, St. Stanislas, and Dewittville to the Chateaugay River, following down this river some 10 miles to its intersection with the first line, thence by same location as the first line to Aubrey.

From Aubrey to the Richelieu River and Lake Champlain four lines are indicated, two of them entirely in Canada and two partly in Canada and partly in the United States, with the locks in the United States.

The first follows up Norton Creek 3 miles, and thence on the westerly slope of higher country to St. Johns on the Lake St. Francis level.

The second follows up Norton Creek 7 miles, keeping north of Canada Atlantic Railway, and crosses the Montreal Junction and Grand Trunk Railway 3 miles north of Canada Atlantic Railway, then easterly to the Little Montreal River, 3¼ miles north of Canada Atlantic Railway. From the Little Montreal River the line leads southeasterly across a ridge of unknown height into Lacolle River, then follows down Lacolle River into the Richelieu River.

The third follows up Norton Creek 10 miles, then crosses easterly into the Little Montreal River, following up this river about 1 mile, then southeasterly through a continuous swamp into the Great Chazy River near Perrys Mills, then down the Great Chazy River into Lake Champlain at Kings Bay.

The fourth follows up the English River from Aubrey about 10 miles, then easterly to the head waters of Little Montreal River, 2 miles south of Hemmingford, thence northeasterly into the third line, and then follows location of third line to Kings Bay.

Two of these routes for possible survey—the St. Johns route, for reason of its great length and the great amount of dredging required in the Richelieu River, and the English River route, on account of the higher elevations over some 8 miles of its course and the great amount of rock and unfavorable soil encountered—may be eliminated from any discussion as to whether any final surveys are feasible or not, and only the Lacolle and the Norton Creek routes considered at this time.

If it is feasible to build a canal anywhere on earth it would seem to be through the 20 miles of country from Lake St. Francis to the junction of the English River and Norton Creek at Aubrey. The soil is clay, with very few bowlders and no rock ledges in sight, and almost any desired level can be found.

[1] See outline map, profile No. 7.

From Aubrey both the Lacolle and Norton Creek lines follow up Norton Creek Valley about 7 miles and then separate. The Lacolle route keeps about 3½ miles north of the Canada Atlantic Railway, on an elevation averaging about 30 feet higher than Lake St. Francis, for 10 miles, to the Little Montreal River; it then circles southeasterly over a ridge of unknown elevation, probably not very high, for 7 miles into the Lacolle River near Lacolle, then follows down Lacolle River 2 miles to the Richelieu River, then up the Richelieu River, where a good deal of dredging will be required, into Lake Champlain, making some 20 miles of excavation besides the dredging in the Richelieu River. This route follows the two legs of a right angle triangle, of which the Norton Creek route is the hypothenuse.

The Norton Creek route follows up Norton Creek Valley about 11 miles, through clay soil for 7 miles, and then through 4 miles of a black muck bog. Leaving Norton Creek at an elevation of 173 feet, it crosses southeasterly for 2 miles over the ridge between Norton Creek and Little Montreal River, at an average elevation of about 184 feet. A limestone ledge comes to the surface on this ridge. The greatest part of the material, however, is clay and black muck. It then follows up the Little Montreal River for about 1 mile through clay and bowlders; highest elevation, 206 feet. It then bears southeasterly for 4 miles through a black muck swamp, crossing on this 4 miles the height of land, elevation of 210 feet. This high elevation is short, only about 1 mile. It now bears nearly south on descending land for 3 miles through a continuation of this black muck swamp into the Great Chazy River near Perry's Mills; elevation about the same as Lake St. Francis, making some 17 miles of elevation above Lake St. Francis, of which it is safe to say that 11 miles are under 30 feet above the lake, and only 2 miles reaching an elevation of 50 feet above the lake.

From Perry's Mills for 5 miles to Cooperville the Great Chazy River is between high and stable clay banks, and no excavation or embankment is needed—simply to dam the river and put in the locks where most convenient. From Cooperville for 1 mile to the lake the banks are low, and dredging will be necessary.

Final and accurate surveys will undoubtedly change some of the data and distances given in this preliminary reconnoissance, but the levels run upon the Norton Creek route are reliable.

A sketch map and approximate profile accompany this report, and are to be considered a part of it.[1]

Very respectfully submitted.

F. M. BARSTOW.

Mr. LYMAN E. COOLEY, C. E.,
Engineer United States Deep Waterways Commission.

BURLINGTON, VT., *June 5, 1896.*

SIR: I have the honor to report that I made the trip as directed in your last letter. I went from Howick on the Grand Trunk Railway up the banks of the Chateaugay River to Huntington, then drove back to Dewittville, and thence through St. Stanislas de Kostka to Lake St. Francis, some 5 miles above Valleyfield.

I can report nothing more favorable than in my first report. In fact, this last trip only confirms what was then reported, viz, a gentle up slope toward the south from the Canada Atlantic Railway. The country is not level to an abrupt hillside, as you hoped it might be.

The banks of the Chateaugay River are from 15 to 25 feet high. Its current is slow, there being three dams and two small rapids between Howick and Dewittville; so I would judge that the river at Dewittville is not over 25 feet higher than it is at Howick.

Between Dewittville and St. Stanislas de Kostka one is far enough south to be beyond the level plain-like country that the Canada Atlantic Railway runs through. The country is rolling, and one goes over some considerable hills.

If it is desirable to use a portion of the Chateaugay River for the canal it would seem advisable to keep some 3 or 4 miles to the north of St. Stanislas de Kostka and enter the Chateaugay River 4 or 5 miles north of Dewittville, thus keeping in a more level country and avoiding the rolling land and hills farther south.

No solid rock showed on the surface, but the tops of all the ridges were covered with bowlders, the soil being usually clay.

The shores of Lake St. Francis are low, as I have heretofore reported.

Very respectfully submitted.

F. M. BARSTOW.

Mr. LYMAN E. COOLEY, C. E.,
Engineer United States Deep Waterways Commission.

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[1] Compiled on sheet, profile No. 7.

III. SOUTH BAY ROUTE—CHAMPLAIN-HUDSON DIVIDE.

The reconnoissance between Fort Ann and South Bay was limited to checking a line of levels run along the highway by the United States Geological Survey. This was done for the Commission by Mr. Thomas A. Paterson, C. E., Whitehall, N. Y., and from his memoranda and other data the following notes are made up.

This location was suggested by Mr. Channey N. Dutton. It leads nearly due north between Putnam and Fort Ann mountains from a point north of Fort Ann some 7 miles to the vicinity of South Bay village, 2 miles from South Bay, and to which the waters of Lake Champlain back in times of high water in the lake. The valley is described as a preglacial channel filled with glacial débris, the removal of which may provide "a feasible route for a ship canal with water running directly from Lake Champlain to the Hudson.[1] The sheets of the United States Geological Survey had not been extended through this valley, but a sketch was furnished showing the line of levels above mentioned. The accuracy of these levels had been questioned by parties who had been on the ground.

Mr. Paterson started from a bench mark at Fort Ann, the elevation of which had been determined by the United States Coast and Geodetic Survey. He found that the plane of reference of the Geological Survey was some 6 feet higher than that of the Coast Survey, which has been adopted for the work of the Commission, and that with this reduction the levels of the Geological Survey were substantially correct.

This line runs for considerable distances above the lowest ground, but the ruling points are given. It appears that for 6 miles or more of this route the elevation is 100 feet and upward above the level of Lake Champlain, and that it is much higher for a short distance, with a maximum exceeding 200 feet. The remaining distance is over low-lying ground, that at the north end being but little elevated above South Bay.

Mr. Paterson's observations lead him to doubt the filling in of the valley at the north end, but he thinks that "there may have been some filling washed in" at the south end. He doubts the utility of the line as compared to the present route by Whitehall, and suggests a full survey if the route is to be considered.

Map No. 11a shows by contours the South Bay route. These contours, as drawn, seem to give the elevations too low, but the data secured have been insufficient to warrant a revision.

That any conditions of fact or treatment that may develop in an exhaustive consideration will lead to the adoption of the South Bay route seems improbable, and yet its examination is incidental to any comprehensive survey of the Champlain-Hudson divide.

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[1] Prof. G. F. Wright, A. A. A. S., at Springfield, Mass., August, 1895.

EXHIBIT B1.

ELEVATIONS FOR THE GREAT LAKES AND FOR THE ST. LAWRENCE AND HUDSON RIVERS.

Notes by J. E. MALONEY, C. E.

Part I. Primary leveling.
Part II. Special discussions.
Part III. Notable elevations, bench marks, and reference planes.
Part IV. Reference planes and depths for harbor and channel improvements.

INTRODUCTION.

In the compilation of profiles and in the reduction of water-level observations it has become necessary to adopt standard elevations, so referred in the several localities to known planes of reference that future changes in elevation, due to greater precision of leveling, can be made without undue confusion. These notes are designed to present, in logical sequence and in brief, the evidence on which accepted elevations are based, and to catalogue the principal points and planes of reference.

All elevations are referred to average sea level, specifically to mean tide at New York City, sometimes stated as at Governors Island, and again as at Sandy Hook. In the present investigation all elevations depend on a certain bench mark at Greenbush, N. Y., as determined by the Coast and Geodetic Survey, and adopted by the Lake Survey in 1880. This bench is the starting point for all levels for the Great Lakes and St. Lawrence River.

Leveling operations were conducted by the several authorities in historical order as follows:

(1) Hudson River from New York to Greenbush by spirit level. United States Coast and Geodetic Survey.

(2) Greenbush to Lake Ontario and through the chain of lakes by spirit and water levels. United States Lake Survey.

(3) Greenbush to Lake Champlain and to Rouses Point, by spirit and water levels. United States Coast and Geodetic Survey.

(4) Rouse Point, along Richelieu River and the St. Lawrence River, from Quebec to Lachine, by spirit level. Department of public works of Canada.

(5) Rouse Point to the St. Lawrence River, at Valleyfield, and thence to Kingston, by spirit level. Department of railways and canals of Canada.

The accuracy of these determinations may be inferred by comparison with the following:

(1) Hudson River, recent leveling by the United States Coast and Geodetic Survey.

(2) Erie Canal system, from Albany to Lake Champlain, to Lake Ontario, and to Lake Erie.

(3) St. Lawrence River, from Rouse Point and from Lachine to Lake Ontario, at Kingston.

(4) Mississippi River, from Gulf of Mexico to Lake Michigan, at Chicago, and Lake Superior, at Duluth, by Mississippi River Commission.

In the following digest the data east of Lake Erie are presented as a whole before proceeding to the upper lakes.

PART I. PRIMARY LEVELING.

MEAN TIDE OR AVERAGE SEA LEVEL.

Mean tide or average sea level at New York City has been established by the following observations of the United States Coast and Geodetic Survey:[1]

(1) Governors Island, N. Y., 1852 to 1879, inclusive.

(2) Sandy Hook, N. J., 1876 to 1881; January, 1882, to August 31, 1884; December 1, 1886, to March 31, 1889, all inclusive.

The mean tide as established at Governors Island was transferred by water level to a mark on the tidal gauge at the foot of Eighteenth street, New York, and used as the plane of origin for the line of levels run up the Hudson River in 1857–58.

The mean tide as established at Sandy Hook and referred to convenient bench marks, has been used as the plane of origin for all levels since. Levels of precision have been run and a chain of bench marks established about New York Harbor and vicinity, and from the bench mark established at Dobbs Ferry, levels of precision were run up the Hudson River in 1894. The Sandy Hook plane was also used as the origin of the transcontinental line.

All the elevations in the following pages are given as above mean tide at New York City, unless otherwise stated.

HUDSON RIVER LEVELS.

In 1857–58 Mr. J. B. Vose, of the Coast and Geodetic Survey, ran a line of levels up the east shore of the Hudson River from the tide gauge at Eighteenth street, New York City, to a bench mark on the gristmill at Greenbush, N. Y.[2] An ordinary wye level was used, and a double line run between stations. When the check was not satisfactory, the line was rerun. The elevation of the bench mark is given as 15.37 feet, with a probable error of ± 0.20 foot as assigned by Mr. Vose,[3] and of ± 0.10 foot by the Superintendent of the Coast and Geodetic Survey.[4] The distance covered was about 147 miles.

In 1875, Lieut. J. B. Willard ran a check line between the Coast and Geodetic bench mark at Stuyvesant and the bench mark on the grist-

[1] Report Coast and Geodetic Survey, 1887. Appendixes 7 and 14.

[2] Other bench marks were established, but all have been destroyed except the bench mark on the gristmill. Report Chief of Engineers, 1876, part 3, page 71, et seq.

[3] Report Coast and Geodetic Survey, 1857, page 352.

[4] Report Chief of Engineers, 1876, part 3, page 71, et seq.

mill at Greenbush, and notes an agreement within 0.50 foot. This line was run with an ordinary wye level and covered a distance of about 20 miles.[1]

A line of levels in connection with the location and construction of the West Shore Railroad, and starting from mean high water at Weehawken, N. J., as established by the Coast and Geodetic Survey, was connected with the plane of mean low water at Albany by the United States engineers. This line was run with the ordinary wye level. The elevation of mean low water at Albany was determined at 2.58 feet.[2] The elevation of the bench mark on the gristmill, as deduced from this value, is 16.01 feet. The distance covered was about 148 miles.

In 1877 Mr. O. H. Tittman, of the Coast and Geodetic Survey, went over part of Mr. Vose's line, using a precise level instrument and employing precise methods. Mr. Tittman ran to the bench mark on the gristmill at Greenbush, and also established an elevation on the lower miter sill of Lock No. 1 of the Erie Canal at Albany, and gives the elevations as follows:[3]

	Feet.
Bench mark on gristmill	14.728
Lower miter sill of Lock No. 1	−6.145

In 1894 the Coast and Geodetic Survey ran a line of precise levels along the Hudson River, starting from the bench mark at Dobbs Ferry. The superintendent gives the elevation of the bench mark on the gristmill as 13.645 feet, with the following note: "The difference between the above (13.645) and any former results is probably due to the more perfect determination of tidal level than to any other cause."[4]

The following table shows the elevation of the bench mark on gristmill at Greenbush, as determined at different times:

Date.	Authority.	Elevation.
		Feet.
1857-58	Mr. J. B. Vose, Coast and Geodetic Survey	15.37
1875	Lieut. J. B. Willard, United States Engineers	15.37 ± 0.50
1877	Mr. O. H. Tittman, Coast and Geodetic Survey	14.728
1889	Deduced from West Shore Railroad levels	16.01
1894	Coast and Geodetic Survey	13.645

The elevation (14.73 feet) for the above bench mark has been adopted by the United States Deep Waterways Commission, for the following reasons:

The Lake Survey used the value 14.73 in deducing the elevations of the Great Lakes, and all published elevations are based on this value.

The Coast and Geodetic Survey used 14.73 in deducing the elevation of Lake Champlain, and all published elevations are based on this value.

Less confusion was likely to arise by adhering to the value heretofore accepted until such time as the entire system of levels could be systematically redetermined. Meantime, elevations can be reduced to the latest determination of the bench mark at Greenbush by subtracting 1.08 feet.

[1] Report Chief of Engineers, 1876, part 3, page 71, et seq.
[2] Report Chief of Engineers, 1890, part 1, page 691.
[3] Report Coast and Geodetic Survey, 1889, Appendix 7, page 171.
[4] Letter of Mr. W. W. Duffield, Superintendent United States Coast and Geodetic Survey, dated March 30, 1896.

ELEVATIONS AT ALBANY BASIN.

The elevation of the lower miter sill of Lock No. 1 (west lock), Erie Canal, at Albany, has been determined as follows:

In 1875 Lieut. J. B. Willard determined the difference of elevation between the miter sill and the bench mark on gristmill as 20.89 feet; elevation of miter sill is, therefore, 14.73—20.89 feet, or —6.16 feet. At the same time the lake survey determined the difference as 20.99 feet, and elevation of miter sill 14.73—20.99 feet, or —6.26 feet.[1]

In 1877 the Coast and Geodetic Survey determined the elevation as —6.145 feet. This is equal to a difference of 14.728+6.145, or 20.873 feet between the miter sill and bench mark.[2]

Using the bench mark as determined in 1894, or 13.645 feet, and the difference as established in 1877, or 20.873 feet, the resulting elevation of miter sill is 13.645—20.873, or —7.228 feet.

In regard to any probable change of this miter sill, the following note is given in the report of the United States Lake Survey, Professional Papers, Corps of Engineers, United States Army, No. 24, page 610:

> The miter sill of west lock has remained unchanged since 1839.

The observations for mean low water as established in 1873 by the United States engineers at Albany Basin give the following depths on miter sill of Lock No. 1:

The arithmeticial mean of six points taken in 1874 is 7.448 feet. (This is 0.18 foot below the low water established in 1867 by Assistant Engineer Talcott, from relatively few observations.[3]) The State engineer and surveyor of New York has adopted a value of 7.443 feet as the plane of mean low water, to be used as canal datum.[4] This appears to be a fair mean for the miter sill as determined by the United States engineers.

The following elevations of mean low water at Albany are deduced by combining the foregoing elevations of miter sill and depth of mean low water as adopted by the State engineer:

	Elevation.
	Feet.
From railroad levels used by United States engineers, 1890–1894	2.58
Used on Hudson River improvements *a*	1.44
Combining miter sill —6.145 and depth of mean low water, 7.443	1.298
Combining miter sill —6.26 and depth of mean low water, 7.443	1.183
Combining miter sill —6.16 and depth of mean low water, 7.443	1.283
Combining miter sill —7.228 and depth of mean low water, 7.443	.215

a Report State engineer and surveyor, New York, 1891, page 293. (This value probably deduced from Talcott's determination of mean low water in 1867.)

In all the deductions made for profiles or tables for the United States Deep Waterways Commission the elevation of mean low water at Albany has been taken as 1.30 feet above mean tide at New York City. This value is used as agreeing with the value 14.73 feet for the bench mark on gristmill, and the mean low water depth as established by the State engineer and surveyor, or 7.443 feet, and the elevation of sill as determined by Mr. Tittman, or —6.145 feet.

[1] Report Chief of Engineers, 1876, part 3, page 72.
[2] Report Coast and Geodetic Survey, 1887, Appendix 7, page 171.
[3] Report State engineer and surveyor, New York, 1875.
[4] Report State engineer and surveyor, New York, 1888.

GREENBUSH TO LAKE ONTARIO.

In 1875 the United States Lake Survey ran a line of levels from the bench mark on gristmill at Greenbush to bench mark A at Oswego, Lake Ontario.[1] The instruments used were ordinary wye levels, and the method was to run two lines by two parties, the second party checking on benches established by the first, and eliminating differences, as far as possible, by rerunning.

The difference of elevation between the bench mark on gristmill and bench mark at Oswego as established by the two parties is as follows:

	Feet.
Party No. 1	236.76
Party No. 2	237.71

For the first 70 miles from Greenbush the total discrepancy between the two lines was but +0.13 foot. But for the remainder of the distance to Oswego, 117 miles, the plus sign predominates, and the total discrepancy increases to +0.95 foot.

The value adopted was a mean of the two, or 237.23 feet, with a probable error of ± 0.32 foot.

The resulting elevation of bench mark A at Oswego is 237.23 + 14.73, or 251.96 ± 0.32 feet, and this is the value adopted by the Lake Survey.

From this value of bench mark A (251.96) the elevation of the lower miter sill of Lock No. 18, Oswego Canal, at Oswego, has been determined by Mr. William Pierson Judson, C. E., as 237.07 feet.[2]

LAKE ONTARIO TO LAKE ERIE.

From bench mark A, at Oswego, elevations were carried by water levels to bench mark B, at Port Dalhousie.

The water leveling comprised a connection between the zero of gauges and the bench marks, and readings of water surface for a certain period. The United States Lake Survey observations on all the lakes for this purpose covered the period from May 11 to August 31, 1875, inclusive.[3] From the comparison of gauge records the relative positions of the zeros were established.

The elevation of bench mark B at Port Dalhousie was determined as 258.05 feet. This bench mark is the zero of gauge at that point. Elevations were also established at several other points about the lake and are noted in table of elevations.

The line of spirit levels from bench mark B, Port Dalhousie, to a bench mark on the custom-house at Port Colborne, by United States Lake Survey, was run with wye levels, and the same method followed as from Greenbush to Oswego. The two parties differed but 0.03 foot at Port Colborne and the mean of the two results was adopted.

The difference of elevation between bench mark B, at Port Dalhousie, and the bench mark at Port Colborne as adopted is 326.59 feet; hence the elevation of bench mark on custom-house at Port Colborne is 258.05 + 326.59, or 584.64 ± 0.32 feet. This elevation of bench mark is 3.87 feet

[1] Report United States Lake Survey, Professional Papers, Corps of Engineers, United States Army, No. 24, page 595 et seq.

[2] Letter Mr. William Pierson Judson, C. E., dated April 22, 1896.

[3] Report United States Lake Survey, Professional Papers, Corps of Engineers, United States Army, No. 24, page 595 et. seq.

above zero of gauge, and the elevation of the zero of gauge is therefore 584.64—3.87, or 580.77 feet.[1]

From these levels the mean surface of Lake Erie (1860–1875) was determined as at an elevation of 572.86 feet and the bench mark on the light-house at Buffalo as 16.95 feet above mean surface, or at an elevation of 589.81 feet.[2]

GREENBUSH TO LAKE CHAMPLAIN.

From the bench mark on gristmill at Greenbush the Coast and Geodetic Survey carried elevations by a line of precise levels to Putnam Station, Lake Champlain, and then by water level to a bench mark on the Chapman block at Rouse Point, called international bench mark.

The levels were run in 1882, by Mr. O. H. Tittman, starting from the miter sill of Lock No. 1, at Albany, as determined by him in 1877. The elevation of the bench mark at Rouse Point was determined as 110.06 feet, and a probable error of ± 0.30 foot deduced for the water levels "exclusive of error due to secular change."[3]

In 1896, Mr. Albert J. Himes, resident engineer, New York canals, established the elevation of the lower miter sill of Lock No. 23, Champlain Canal, at Whitehall, from Coast and Geodetic bench mark No. 36, and gives the elevation as 85.92 feet.[4]

CANAL LEVELS.

In connection with the construction and maintenance of the canals of New York, lines of levels have been run from Lock No. 1 at Albany through to Oswego on Lake Ontario, Buffalo on Lake Erie, and Whitehall on Lake Champlain. In 1876 a rerunning of the bench marks along the several canals was ordered. The work was done with ordinary wye levels by the several division engineers and great care was taken. The elevations of the bench marks, as determined, have been published in the various annual reports of the State engineer and surveyor.[5] The zero or datum used in all these levels is the plane of mean low water at Albany Basin. In using canal levels elevations have been reduced to mean tide at New York City by adding 1.30 feet, as heretofore determined.

From the canal bench marks the lower miter sill of Lock No. 18 at Oswego has been determined as 236.43 feet above canal datum or 236.43 + 1.3 feet = 237.73 feet above mean tide at New York City.[6]

The mean surface of Lake Erie (1860–1875) and of the upper and lower miter sill at Blackrock have been determined from canal levels and their corresponding elevation above mean tide at New York are as follows:[7]

	Feet.
Upper miter sill of guard lock at Black Rock	561.59
Lower miter sill of guard lock at Black Rock	561.63
Mean surface, Lake Erie, 1860–1875	573.53
Bench mark on Buffalo light-house	590.48

[1] Report United States Lake Survey, Professional Papers, Corps of Engineers, United States Army, No. 24, page 595 et seq.

[2] Letter Capt. T. W. Symons, Corps of Engineers, United States Army, dated Buffalo, March 25, 1896.

[3] Report Coast and Geodetic Survey, 1887, April 7, page 171.

[4] Letter from Mr. A. J. Himes, C. E., dated April 9, 1896.

[5] Reports of State engineer and surveyor of New York, 1888, 1889, and 1892.

[6] Letter, Mr. A. J. Driscoll, first assistant engineer New York canals, dated August 25, 1896.

[7] Letters, Mr. G. W. Rafter, C. E., engineer New York canals, and of J. L. Little, division engineer, dated Rochester (February to March), 1896.

The elevation of the lower miter sill of Lock 23 at Whitehall, as determined from canal levels by Mr. Albert J. Himes, resident engineer, New York canals,[1] is 84.981 feet above canal datum, or 84.98+1.3=86.28 feet above mean tide at New York City. This value 86.28 is corrected by the discrepancy discovered in reviewing the Champlain Canal levels, as noted by Mr. Himes.

On the Welland Canal there are no data at hand to show any line of levels.

The general report of the minister of public works for Canada, 1867 to 1882, page 299, gives the absolute difference between miter sills of the locks at Port Dalhousie and Port Colborne as 327.96 feet.

Mr. Thomas Monro, engineer Soulanges Canal,[2] gives the elevation of the sills of the two locks as follows:

	Feet.
Lower miter sill new lock at Port Dalhousie	230.20
Lower miter sill new lock at Port Colborne	557.63

This makes the difference 327.43 feet. These elevations of miter sills are deduced from the United States Lake Survey elevations of bench marks.

In the letter mentioned above, Mr. Monro gives a depth of 13.49 feet on the sill of old lock at Port Dalhousie as corresponding to the mean lake surface (1860–1875) as established by the United States Lake Survey. The old lock sill is 2.92 feet above the new, hence the sill of new lock is 246.61—(13.49 + 2.92) or 230.20 feet above mean tide at New York.

RICHELIEU AND ST. LAWRENCE RIVERS (ROUSE POINT, LACHINE, AND QUEBEC).

In 1883–84 Mr. R. Steckel, C. E., engineer in charge of geodetic leveling for the department of public works, Canada, ran a line of precise levels from the bench mark on the Chapman block at Rouse Point to Sorel, at the mouth of the Richelieu River, and continued the line in 1885–86 to Lachine and Quebec on the St. Lawrence River. Mr. Steckel refers all his elevations to an assumed mean tide at the Gulf of St. Lawrence, as established by him from tidal observations at Quebec in 1881–82.[3] The bench mark on Chapman block, Rouse Point, N. Y., is common to Mr. Steckel's and the Coast and Geodetic levels, and its elevation as established by the two lines is as follows:

	Feet.
By the United States Coast and Geodetic Survey, above mean tide at New York	110.06
By the department of public works, Canada, above mean tide Gulf of St. Lawrence	114.50

As shown by the comparison, Mr. Steckel's datum plane is 4.44 feet below mean tide at New York, and all his elevations should be reduced by this amount. In the following table all elevations are given in two columns, one referred to mean tide at New York and the other to Mr. Steckel's datum plane.

[1] Letter of Mr. A. J. Himes, C. E., dated September 8, 1896.
[2] Letter of Mr. Thomas Monro, C. E., dated September 2, 1896.
[3] Reports minister of public works, Canada, 1884–85 and 1890–91.

Elevations on the St. Lawrence River at Lachine, Montreal, and Quebec.

Description.	Mr. Steckel's datum.	Mean tide at New York.
Lower miter sill Lock No. 5, at Lachine:		
New, north side	57.78	53.34
Old, south side	62.83	58.39
Lower miter sill Lock No. 1, at Montreal:		
New	9.61	5.17
Old	11.54	7.10
Zero of harbor commissioners' gauge at Sorel, nearly		— 4.44
Zero of Quebec harbor commissioners' gauge	— 0.02	— 4.46
Zero of Levis, Graving Dock gauge	— 8.62	—13.06
Mean tide level at Quebec for low-water season *a*	+ 6.99	+ 2.55
Mean high-tide level at Quebec for low-water season	+13.942	+ 9.50
Lowest trough of tides at Quebec (springs or neaps) at time of lowest normal water (16 feet on miter sill Lock No. 1)	— 1.67	— 6.11

a Report minister of public works, Canada, 1890-91.

Mean amplitude of tides at Quebec (low-water season), 13.88 feet; and half tide, 6.94 feet.

The elevations of tides at Quebec and at Albany, referred to mean sea level at New York, are as follows:

Tides.	Quebec.	Albany.
Mean	2.55	2.46
Mean low	— 4.39	1.30
Mean high		
Amplitude of	13.88	2.32

ST. LAWRENCE RIVER (ROUSE POINT, VALLEYFIELD, AND KINGSTON).

In 1891 Mr. Thomas Monro, engineer Soulanges Canal, ran a line of levels from Rouse Point to Valleyfield at Lake St. Francis. The instrument used was an ordinary Y level, and the method employed was to run several lines and obtain a mean. Mr. Monro used the Coast and Geodetic elevation of 110.06 feet at Rouse Point, and his elevations are therefore in feet above mean tide at New York City. This line of levels gives the mean surface of Lake St. Francis at Valleyfield an elevation of 154.80 feet.[1] The miter sill of the lock at Valleyfield is given as 142.52 feet.[2]

From Lake St. Francis at Valleyfield to Prescott, and thence to Kingston, Mr. Monro ran a line of levels in 1894–95. Concerning this line, (Kingston to Prescott) Mr. Monro says:[3]

The instruments were of the ordinary kind, and no attempt was made at precise leveling, but there were three through lines run, sometimes six, between bench marks where there was any considerable discrepancy.

Concerning the balance of the line from Prescott to Lake St. Francis, Mr. Monro says:

Continuing the levels to Lake St. Francis, we make the total fall to be about 91.50 feet (fall from Lake Ontario to Lake St. Francis at Valleyfield). Thus 154.80 + 91.50 = 246.30 feet instead of 246.61 feet (246.61 feet is the mean level of Lake Ontario for the period 1860–1875). This, under the circumstances, is a fairly accurate close, and it precludes the possibility of serious error.

The above comparison is between mean water surfaces for different periods and exhibits the general result only.

[1] Letter Mr. Thomas Monro, engineer Soulanges Canal, dated September 2, 1896.
[2] Profile St. Lawrence River, by Thomas Monro, engineer Soulanges Canal.
[3] Letter dated September 4, 1895, through Mr. John Kennedy, chief engineer, Montreal harbor commissioners.

Under date of September 2, 1896, Mr. Monro says:

> The lines continued from Rouse Point to Kingston showed the zero of the gauge at the dry dock there to be 244.81 feet over mean tide at New York. A connection was made between this point and both Charlotte and Oswego, as shown.[1]

The zero of gauge at Kingston dry dock is given as 244.81 feet above mean tide at New York. A mean of the water level of Lake Ontario for four years, 1891–1894, at Kingston, as furnished by Mr. Monro, gives an average reading of 0.92 foot above zero of gauge. The same period at Oswego gives an average reading of 1.69 feet above zero; hence the Kingston zero of gauge is 1.69 — 0.92, or 0.77 foot above the zero of gauge at Oswego, and is at an elevation of 244.21 + 0.77 = 244.98 feet by United States Lake Survey levels. The elevation as determined from Oswego is 0.17 foot higher than given by the St. Lawrence levels.

The slope in river surface from Kingston to Prescott is given by Mr. Monro as 0.25 foot.[2]

The elevations used by the United States Deep Waterways Commission for the St. Lawrence River from Ogdensburg to Lake St. Louis are based on Mr. Monro's determination, and from Lachine east the elevations depend on Mr. Steckel's levels corrected by the difference in datum planes, or 4.44 feet.

LAKE ERIE TO LAKES HURON AND MICHIGAN.

From Port Colborne the Lake Survey carried elevations by water level to the west end of Lake Erie to a gauge at Rockwood, and transferred to bench mark 2 at Gibraltar (about 2 miles) by spirit level. Elevations were also established at several other points about the lake and are noted in table of elevations.[3]

For the purpose of eliminating wind effects, observations were made as to the direction and force of prevailing winds during the period May to August, 1875, in order to determine a correction. The results deduced are given by the Lake Survey as probably correct within ± 0.10 foot.

From bench mark 2 at Gibraltar the Lake Survey ran two lines to bench mark 2 at Lakeport, Lake Huron; the first, a double line in 1875 with ordinary wye levels; the second, in 1877 by precise leveling. The results obtained in 1877 have been adopted, and the elevation of bench mark 2 at Lakeport is 590.86 ± 0.35 feet. Bench marks were estabilshed at Detroit and are given in the table of elevations appended.

From Lakeport the elevations were carried by water level to bench mark 1 at Escanaba, and the elevation determined as 593.01 feet. Bench marks were also established at several other points, and are noted in the table of elevations.

In transferring by water level, Lakes Huron and Michigan were assumed, for reasons given in the final report of United States Lake Survey,[4] to be level. In regard to this assumption it should be noted that, taking the twenty-five years—1871–1895—the average of the monthly means for the two lakes shows Lake Michigan to be from 0.04 to 0.11 foot above Lake Huron for the months September to January

[1] See Part II.

[2] See letter September 2, 1896; also "Water levels, Great Lakes," etc.

[3] Report United States Lake Survey, Professional Papers, Corps of Engineers, United States Army, No. 24, page 595 et seq.

[4] Report United States Lake Survey, Professional Papers, Corps of Engineers, United States Army, No. 24, page 595 et seq.

inclusive; at about the same level for February; from 0.05 to 0.12 foot below from March to June inclusive, and at about the same level during July and August.[1]

LAKE MICHIGAN TO LAKE SUPERIOR.

From bench mark I at Escanaba a double line of precise levels was run in 1877 to bench mark I at Marquette. The resulting elevation of bench mark I is given as 609.93 ± 0.36 feet. From the bench mark at Marquette the elevation was carried by water levels, as on the other lakes, to several points about the lake and to St. Marys River at Sault Ste. Marie. The transfer of elevations from Marquette to the canal at Sault Ste. Marie was made on the assumption that there was no slope in the river. This assumption is now known to be in error, and the slope, at the time the elevations were established, has been determined as 0.58 foot. (See "Water Levels of the Great Lakes," etc.) This correction of —0.58 foot applies to bench marks established about Sault Ste. Marie by the Lake Survey, and to all deductions for water levels, elevations, and planes of references made therefrom.

GULF OF MEXICO TO LAKE MICHIGAN AT CHICAGO.

In 1883 the Mississippi River Commission continued its line of precise levels to Chicago, Ill., and established bench marks. The results obtained are compared with the results of the Lake Survey at Milwaukee by the following method:

A bench mark designated B. M. No. 99 was established by the Mississippi River Commission levels on the stone freight depot of the Illinois Central Railroad at Chicago, with an elevation of 611.45 feet above Cairo datum. The mean level of the Gulf of Mexico at Biloxi, Miss., above Cairo datum is given at 21.26 feet. (This is to be taken as a preliminary value.) Hence, bench mark No. 99 at Chicago is 611.45 — 21.26, or 590.19 feet above mean Gulf level.

The plane of reference for water levels, Lake Michigan, or observed high water of 1838 at Milwaukee, has been determined as at an elevation of 584.34 feet above mean tide at New York City. (See "Water levels of the Great Lakes," etc.)

The water levels observed on the United States engineers' gauge at Chicago are compared with the recorded observations at Milwaukee for the years 1892 to 1895, inclusive. The records are as follows:

	1892.		1893.		1894.		1895.	
	Chicago.	Milwaukee.	Chicago.	Milwaukee.	Chicago.	Milwaukee.	Chicago.	Milwaukee.
January	—0.12	4.87	0.05	4.75	0.21	4.47	—0.02	4.82
February	.16	4.68	.09	4.61	.29	4.44	— .10	4.93
March	.00	4.78	.17	4.50	.42	4.18	— .24	4.96
April	.08	4.72	.48	4.04	.74	4.03	— .02	4.76
May	.35	4.30	.88	3.74	1.17	3.49	.07	4.60
June	.72	3.85	1.23	3.41	1.35	3.33	.08	4.55
July	.95	3.84	1.35	3.39	1.47	3.30	.02	4.66
August	1.06	3.76	1.31	3.56	1.33	3.38	— .08	4.78
September	.79	3.96	1.01	3.88	.95	3.81	— .28	5.05
October	.54	4.20	.73	4.02	.66	4.02	— .59	5.42
November	.34	4.47	.34	4.41	.49	4.29	— .84	5.64
December	.08	4.74	.16	4.48	.20	4.64	— .93	5.75
Mean	.41	4.35	.65	4.07	.77	3.95	— .24	4.99

Zero of United States engineers' gauge at Chicago below high water, 1838: In 1892, 4.76 feet; in 1893, 4.72 feet; in 1894, 4.72 feet; in 1895, 4.75 feet.
Mean for the four years, 1892–1895, 4.74 feet.

[1] See "Water levels of the Great Lakes," etc., and diagram No. 3

Taking the mean of the four years, the zero of the United States engineers' gauge at Chicago is 4.74 feet below the high water of 1838, and its elevation is 584.34 — 4.74, or 579.60 feet above mean tide at New York City. From information furnished by Maj. William L. Marshall, Corps of Engineers, United States Army, at Chicago, the zero of the gauge is 11.622 feet below bench mark No. 99. Hence bench mark No. 99 is 579.60 + 11.622, or 591.222 feet above mean tide at New York City. The comparison, therefore, is:

	Feet.
Bench mark No. 99, Chicago, by Lake Survey, above mean tide at New York.	591.22
Bench mark No. 99, Chicago, by Mississippi River Commission, above mean level, Gulf of Mexico	590.19

GULF OF MEXICO TO LAKE SUPERIOR AT DULUTH.

The line of precise levels by the Mississippi River Commission was continued to St. Paul in 1891. A line was then run from Duluth, on Lake Superior, to St. Paul, connecting with the main line of levels there.[1]

A comparison of the elevations of bench mark I at Duluth, as established by the Lake Survey and by the Mississippi River Commission, is made as follows: In a letter from Maj. Clinton B. Sears, Corps of Engineers, U. S. A., dated March 6, 1896, the low-water datum is described as 25.528 feet below bench mark I at Duluth, and the "High water of 1838," as used for plane of reference by the Lake Survey after 1874, is given as 3.57 feet above the low-water datum; hence, bench mark I at Duluth is 25.53 — 3.57, or 21.96 feet above the plane of reference, or "High water of 1838," as established by the Lake Survey.

The "High water of 1838" is described (See "Water levels of Great Lakes," etc.) as being 5.17 feet below bench mark I at Marquette, or at an elevation of 609.93 — 5.17 = 604.76 feet. Bench mark I at Duluth is, therefore, at an elevation of 604.76 + 21.96 feet, or 626.72 feet above mean tide at New York City.

From the line of precise levels by the Mississippi River Commission, the elevation of bench mark I at Duluth is given as 647.09 feet above Cairo datum, and as Cairo datum is 21.26 feet (preliminary value) above mean Gulf level, bench mark I at Duluth is 647.09 — 21.26 feet, or 625.83 feet above mean level of Gulf of Mexico.[2]

The comparison, therefore, is:

	Feet.
Bench mark I at Duluth, by Lake Survey, above mean tide at New York	626.72
Bench mark I at Duluth, by Mississippi River Commission, above mean level Gulf of Mexico	625.83

DISCUSSIONS OF DISCREPANCIES.

All the work of the Commission is based on the elevation of the Coast and Geodetic Survey bench mark on the gristmill at Greenbush, N. Y., which is taken as 14.73 feet above mean tide at New York City, as adopted by the Lake Survey and as used by the Coast and Geodetic Survey in their Champlain line. The Canadian levels have been reduced to correspond to this elevation. It will be useful to compare the determinations by different lines.

The latest determination of the Greenbush bench mark (1894) by the Coast and Geodetic Survey is by methods of precision, and lowers the elevation by 1.08 feet.

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[1] Report of Mississippi River Commission, 1891.

[2] Reports of Chief of Engineers, 1883, 1884, and 1885. Report of Mississippi River Commission, 1891.

The lines of the Mississippi River Commission from the Gulf of Mexico at Biloxi, Miss., to Lake Michigan at Chicago and to Lake Superior at Duluth, are by methods of precision. The reference to mean gulf level is provisional, but it is not anticipated that it will be materially changed by the final determination.

The comparison heretofore made gives elevations at Chicago, referred to mean gulf level, as 1.03 feet lower than when referred to the plane of the Lake Survey. If the Lake Survey plane is corrected by the latest determination of the Greenbush bench mark, then the comparison is, $1.03 - 1.08 = -0.05$ foot, or elevations at Chicago are 0.05 foot higher, referred to mean gulf level.

A second comparison may be made at Duluth. This is less direct as the Lake Survey determination involves two stretches of water levels, Chicago to Escanaba and Marquette to Duluth, aggregating 460 miles, and levels of precision between Escanaba and Marquette, 105 miles; while the levels of precision of the Mississippi River Commission from Chicago to Duluth extend, via Savanna and St. Paul, 585 miles. The comparison gives elevations at Duluth, referred to mean gulf level, as 0.89 foot lower than when referred to the plane of the Lake Survey. If the plane of the Lake Survey is corrected by the latest determination of the Greenbush bench mark, then the comparison is $0.89 - 1.08 = -0.19$ foot, or elevations at Duluth are 0.19 foot higher, referred to mean gulf level.

Considering the two lines as originating at Chicago, the close at Duluth is, $1.03 - 0.89 = 0.14$ foot; or the water and land line of the Lake Survey gives an elevation of 0.14 foot less at Duluth than the land line of the Mississippi River Commission. This is a remarkable result and precludes the possibility of serious error in the level of Lake Superior with respect to Lake Michigan.

The comparison at Chicago is to be considered as most valid, as it involves less length of line and fewer transfers between land and water lines. It appears that if the plane of the United States Lake Survey is lowered by 1.08 feet to correspond with the latest determination of the bench mark at Greenbush, the new elevation will be within 0.05 foot of the determination from gulf level at Chicago.

The investigation of water levels (see "Water Levels," etc. and Diagram No. 3) shows that Lake Michigan and Lake Huron stand at the same level for only three months of the average year. It so happens, however, that the water-level comparison made by the Lake Survey is a fair mean for the twenty-five years (1871–1895) and no discrepancy appears in the relative level of Lakes Michigan and Huron as heretofore adopted.

Between Lake Huron and Lake Erie, two lines of levels were run over a distance of 88 miles from Gibraltar to Lakeport; the first in 1875 by ordinary wye levels, the second in 1877 by levels of precision. These lines agree within 0.26 foot, and there is no reason to distrust the accuracy of the determination by precise levels.

Between Gibraltar and Port Colborne the determination by water levels is to be taken with caution. Mr. W. T. Blunt in his paper, "Effects of Gales on Lake Erie," has drawn attention to the unstable surface of this lake and the probability that the average level is actually higher at the easterly end than at the westerly. Any such condition would make the apparent elevation at Gibraltar higher than the actual with respect to Port Colborne.

The Lake Survey in its water levels considered wind effects, and these appear to have been eliminated in the records used in the compar-

ison of 1875. In this connection it is interesting to note that the mean reading at Gibraltar for June and July, 1895, as furnished by the United States engineer office at Detroit, is 0.19 foot higher than the mean for the same period as recorded at Cleveland.

Any final correction of the water levels of Lake Erie, if required, will probably reduce the adopted elevation at Gibraltar with respect to Port Colborne.

Between Lake Erie at Buffalo and Lake Ontario at Oswego the Lake Survey line by water level from Oswego to Port Dalhousie, ordinary wye levels along the Welland Canal and water levels from Port Colborne to Buffalo, checks closely with the canal levels by Oswego Canal to Syracuse and Erie Canal thence to Buffalo, the discrepancy being only 0.01 foot. This is better than is to be expected from methods of precision.

The work between Lake Ontario and the bench mark at Greenbush, N. Y., is far less satisfactory than any portion of the levels under consideration. Starting from Greenbush as a point of origin, Lake Ontario may be given four values by the several lines and combinations of lines. In the following comparisons the levels are also given from the lower miter sill of Lock No. 1 at Albany basin to the lower miter sill of the terminal lock at Oswego:

	Above bench mark at Greenbush.	Difference of miter sills.
1. By Erie and Oswego Canal levels	223	243.875
2. By Lake Survey, Line No. 2	222.82	243.81
3. By Lake Survey, Line No. 1	221.87	242.86
4. By Coast and Geodetic Survey to Rouse Point and thence by department of railways and canals of Canada to Kingston	222.17	243.045

The Lake Survey lines make the miter sill at Albany basin lower by 0.12 foot which accounts for the relative discrepancy in the second column.

The Lake Survey adopted the mean of its two lines, or 222.34 feet for difference of bench mark and miter sill and 243.33 for difference in miter sills.

If the canal line be regarded as having equal weight, the mean of the three Mohawk Valley lines would be 222.56, an increase in elevation at Oswego of 0.22 foot.

Between Albany and Little Falls several bench marks have been identified as on the copings of the same locks as canal bench marks, and although these are not known to be identical, they probably do not differ more than a few hundredths and may be used for an approximate comparison. The following table gives the discrepancy of the two Lake Survey lines in relation to the canal line:

	No. 2.	No. 1.	Mean.
Maximum discrepancy, Lock 28, 50 miles from Greenbush	—0.88	—0.92	—0.90
Discrepancy at Lock 36, 87 miles (last common B. M.)	— .36	— .78	— .57
Discrepancy, miter sill, Oswego	— .18	—1.13	— .66

The two Lake Survey lines check closely to Lock 28, where they differ only 0.04 foot, but they have systematically diverged from the canal line until the mean discrepancy has reached 0.90 foot. The two lines

continue to check closely for 20 miles farther, with a difference of 0.13 foot when they show a systematic divergence amounting to 0.42 foot at Lock 36 and 0.95 foot at Oswego. Meantime, one of the lines (No. 2 above) has very nearly come back to the canal elevation at Oswego (—0.18) and the other has increased its discrepancy by 0.21 foot but has held more nearly parallel to the canal determination.

The canal levels, Oswego to Syracuse, are part of a circuit closing with the Lake Survey at Buffalo, and are assumed to be correct. No material error should exist in the canal levels over the long reaches between Syracuse and Frankfort, 14 miles west of Lock 36, the last common bench mark. It may be assumed, therefore, that the canal levels are more nearly correct from the point at which the lines of the Lake Survey diverge. The following comparisons may be made:

1. Mean of Lake Survey lines to Lock 28 and canal line thence to Oswego, $223 - 0.90 = 222.10$ feet.

2. Mean of Lake Survey lines to Lock 28 and mean of Lake Survey No. 1 and canal, thence to Oswego, $223 - \frac{1}{2}(0.90 + 1.11) = 222$ feet.

The first result lowers the adopted plane at Oswego by 0.24 foot and the second by 0.34 foot.

The precise-level line from Greenbush to Lake Champlain gives the miter sill at Whitehall 0.36 foot lower than by canal levels. No reason appears for questioning the determination. Any effect of southerly winds on the water levels between Putnam Station and Rouse Point would give the Rouse Point elevation apparently too low. From Rouse Point to Kingston ordinary methods were used, but discrepancies were eliminated by rerunning. The Champlain-St. Lawrence chain of levels, as an individual line, would seem to be entitled to more confidence than any one of the Mohawk Valley lines.

These determinations may be compared as follows:

Combined line, Lake Survey and canal	222.10
Champlain-St. Lawrence line	222.17
Lake Survey mean line—adopted value	222.34

It would seem as if the Lake Survey determination had been taken too high. No sufficient reason appears for adopting a new value, and a final determination is not likely to greatly change the result.

CONCLUSION.

The foregoing discussion indicates the levels between Greenbush and Lake Ontario and through Lake Erie as the weakest links in the chain of levels extending by the Lakes from the Atlantic Ocean at Sandy Hook to the Gulf of Mexico at Biloxi. To give the line equal value throughout, levels of precision are required between Greenbush and Lake Ontario and between Lake Ontario and Georgian Bay. Until final determinations are closed it will not be known how far results are apparent only, and how far they may be actual.

Meantime, if the plane of reference adopted by the Lake Survey and as used in the investigations of the Deep Waterways Commission is lowered by an even foot, it will be 0.08 foot higher than the latest determination of the Coast and Geodetic Survey at Greenbush, N. Y., 0.03 foot higher than the determination of the Mississippi River Commission at Chicago, and 0.11 foot lower than the determination of the Mississippi River Commission at Duluth, and is as likely to be correct as any other value in advance of final results.

PART II. SPECIAL DISCUSSIONS.

MEAN LEVEL, GULF OF MEXICO.

Mean level was established by observations at Biloxi, Miss., from June to September, 1882, "which period is free from the effects of the high northerly winds." According to the line of precise levels[1] run by the Mississippi River Commission in 1882 from New Orleans to Biloxi, this mean level is 21.258 feet above Cairo datum. This value (21.26 feet) is to be taken as provisional only. Cairo datum, as used by the Mississippi River Commission, is a plane 300 feet below ordinary low water of the Mississippi River at Cairo, or a stage corresponding to a reading of 9.16 feet above zero of gauge.[1]

As observed from September 7, 1881, to November 24, 1882, and connected by a line of precise levels by the Coast and Geodetic Survey in 1886, from New Orleans to Biloxi, the mean level is 20.846 feet above Cairo datum.[2]

The mean stage of the gulf for sixteen lunations, September 8, 1891, to October 19, 1892, reads 3.353 feet above zero of the Port Eads gauge, and according to Mississippi River Commission precise levels of 1892 and 1893, the zero of the Port Eads gauge is 17.733 feet above Cairo datum. Hence the mean gulf level at Port Eads, La. (mouth of the Mississippi River at South Pass), is 17.733 + 3.353, or 21.086 feet above Cairo datum.[3] The three determinations compare as follows:

	Feet.
1882, at Biloxi, Miss., by Mississippi River Commission	21.258
1881-82, at Biloxi, Miss., by Coast and Geodetic Survey	20.846
1891-92, at Port Eads, La., by Mississippi River Commission	21.086

The first result (21.258 feet) has been used as a provisional value in reducing the levels of the Mississippi River Commission. Some uncertainty has attached to the value of these determinations owing to instability in the Mississippi delta.

TIDES OF THE ST. LAWRENCE RIVER.

From tidal observations made in 1882 at Quebec, Mr. R. Steckel determined approximately the mean level of the Gulf of St. Lawrence, and used that level as the datum plane for all elevations determined by him. The method employed was as follows: Assuming a tideless river, a slope was figured, and the water surface at Quebec (with 16 feet on the miter sill of old Lock No. 1 at Montreal) determined as 1.15 feet above mean gulf level. From the tidal observations it was determined "that when the tidal undulation passes opposite the ancient capital, it partakes already much more of the nature of a wave of translation than of that of oscillation, considering that on an average about ten-elevenths of its total amplitude are above the level which the river would assume if abstracted from tidal influence, or say the level of the tideless river, and only one-eleventh below it."[4]

Mr. Steckel's datum is 4.44 feet below that of the United States Lake Survey as used in these investigations and 5.52 feet below mean tide at New York according to the latest determination of the United States Coast and Geodetic Survey.

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[1] Report Mississippi River Commission, 1883.
[2] Report Coast and Geodetic Survey, 1887, Appendix 9.
[3] Report Chief of Engineers, United States Army, 1894, page 2794 et seq.
[4] Annual report of the minister of public works, Canada, 1890-91.

The following record of the tides of the St. Lawrence River is taken from a report by Mr. R. Steckel, engineer in charge of geodetic leveling, and published in Report of the Minister of Public Works, Canada, 1890–91. Two series are given: During a low-water season, October 12 to November 10, 1887, and during a high-water season, May 4 to June 3, 1888.

The average depth of water on miter sill of old Lock No. 1 at Montreal during the tidal observations of 1887–88 at Quebec was as follows:

	Depth on miter sill.	Elevation.	
		Mr. Steckel's datum.	Mean tide at New York.
	Feet.	*Feet.*	*Feet.*
October, 1887	16.40	27.94	23.50
May, 1888	23	34.54	30.10

Low-water season.

Miles.	Station.	Mean tide above St. Lawrence datum.	Mean tide above mean tide at New York.	Mean amplitude.
		Feet.	*Feet.*	*Feet.*
0	Quebec, Levis Graving Dock	6.987	2.546	13.877
13.5	St. Nicholas	7.474	3.033	13.413
37.5	Pointe Platon	9.539	5.098	11.766
48.8	Grondines	11.855	7.414	7.499
54	St. Jean Des Chaillons	13.201	8.760	5.333
61.8	Batiscan	15.149	10.708	2.532
69	Champlain	16.091	11.650	1.887
80.8	Three Rivers			0.50–1.26

High-water season.

Miles.	Station.	Mean tide above St. Lawrence datum.	Mean tide above mean tide at New York.	Mean amplitude.
		Feet.	*Feet.*	*Feet.*
0	Quebec, Levis Graving Dock	8.955	4.514	13.279
13.5	St. Nicholas	10.352	5.911	12.766
37.5	Pointe Platon	13.688	9.247	10.438
48.8	Grondines	18.130	13.589	4.753
54.0	St. Jean Des Chaillons	19.900	15.459	2.980
61.8	Batiscan	22.529	18.088	1.275
69.0	Champlain	23.750	19.309	.960
80.8	Three Rivers			0.15–0.58

	Feet.
Maximum amplitude at Quebec:	
Low-water season	17,688
High-water season	16,441
Minimum amplitude at Quebec:	
Low-water season	10,949
High-water season	10,752

These results (excepting that at Three Rivers) are deduced from observations of 114 tides, 57 during the low-water season, and 57 during high water. The results have been corrected for diurnal inequalities. A comparison of the tides at Quebec and those at Albany is given in Part I.

SAULT STE. MARIE.

The plane of reference at Sault Ste. Marie has been reduced 0.58 foot below that heretofore in use for reasons described in full in the paper on "Water levels for the Great Lakes and St. Lawrence River." This plane was originally established by the Lake Survey by water levels and assumed the St. Mary's River above the canal to be without slope.

A line of precise levels had been carried from the canal to a gauge at Waiska Bay at the head of the St. Marys River, and the gauge read for ninety-six consecutive days in 1892. The average of these readings was compared with the average for the same period at Marquette. Thus by means of the water line and precise levels a complete connection was made between the bench mark at Marquette and the bench mark on the coping of the lock at Sault Ste. Marie, and it was found that the latter bench mark had been taken 0.58 foot too high.

In regard to this determination the following extract is from a letter by Lieut. J. B. Cavanaugh, United States engineer office, Detroit, under date of August 19, 1896: "I have to say that a thorough investigation has convinced me that your conclusions in reference to the matter are correct."

CHICAGO CITY DATUM.

This is of special interest as being the "low water of 1847," so often referred to as a reference plane in place of the high water of 1838. This plane was established by the trustees of the Illinois and Michigan Canal (opened in 1848) by a bench mark on the entrance lock at Bridgeport where the canal joined the Chicago River in the southwest portion of the present city of Chicago. Mr. Horace M. Singer, who was on the engineering staff of the canal during its construction, from 1836 to 1848, and was subsequently superintendent of repairs, states that canal datum was in reality established in 1836, when construction was begun, and that the relation of this datum to the "low water of 1847" is merely a coincidence. This bench mark, however, was the origin of all bench marks for the city of Chicago. It was destroyed in 1882, but previous thereto its elevation was transferred to the canal collector's office and to two auxiliary benches, one at the West Side Pumping Works and the other at the canal pumping station.

The sanitary district precise levels start with the bench mark on the canal collector's office and extend down the Illinois Valley for 50 miles. When this was adopted in 1890–91, it checked with the bench mark at the West Side Pumping Works within 0.003 foot and with canal pumping works within 0.019 foot. The latter has doubtless suffered some settlement owing to the green masonry on which it was originally taken. This plane may therefore be considered as the original canal datum.

The bench marks generally about Chicago are subject to many discrepancies, due in part to the unstable substrata of the city. Other than those above described, the most reliable are the group at the lake shore, at and near the Chicago Avenue Pumping Station, which have been checked on the bench mark on shaft of the crib, 2 miles from shore, by water levels determined by hook gauges through the water tunnels. Originally the crib bench was carried from the shore by spirit levels through the tunnel. The elevation was not checked from the West Side Pumping Works by hook gauges in 1878, as was done between the shore and the crib.

The bench marks at the Chicago Avenue Pumping Station were used by the Mississippi River Commission in their line of precise levels as the determination of city datum and in comparison with Milwaukee for a connection with the plane of the Lake Survey. In this comparison the gauge readings as taken inside the crib were given a constant correction due to the influx of water through the ports. This correction is, however, very uncertain, owing to the variation in the volume of water pumped at different hours of the day and on different days of the week. The comparison herein made (see Part I) is free from the above error and is to be taken as a more reliable determination.

It appears from this comparison (see Water Levels, etc.) that Chicago datum, or "low water of 1847," corresponds to the mean of eight months, April to November, inclusive, of 1847, as observed by Dr. I. A. Lapham at Milwaukee.

The precise levels of the sanitary district of 1890–91 develops a discrepancy between the datum of the sanitary district as adopted from the original benches and Chicago datum as used at the crib and the Chicago Avenue Pumping Station and as adopted in the levels of the Mississippi River Commission. This discrepancy at bench mark No. 99, used in setting the United States engineers' gauge and in the Milwaukee comparisons, is 0.048 foot. The mean discrepancy in eight bench marks common to the two lines is 0.049 foot.

As the precise line of the sanitary district checked back on the original bench mark within 0.011 foot, this discrepancy (within allowable limits on precise levels) can not be ascribed to the leveling of 1890–91. Sanitary district datum and original city datum is, therefore, to be taken as 0.048 foot lower than the value heretofore used by the Mississippi River Commission and by the United States engineers in harbor improvement, and as used in the comparisons made in the work of this Commission.

The matter has been deemed worthy of extended comment on account of the new outlet proposed by the works of the sanitary district and further extension of a line of precise levels through the Illinois Valley.

WELLAND CANAL.

The miter sills and coping of the entrance locks of the Welland Canal are referred to mean level of Lakes Erie and Ontario for the years 1860–1875. The following information is furnished by Mr. Thomas Monro, engineer Soulanges Canal, who was for many years upon the work of enlarging the Welland Canal:

	Feet.
Miter sill, old lock, Port Dalhousie, below mean level Lake Ontario, 1860–1875.	13.49
Coping, old lock, Port Dalhousie, above mean level Lake Ontario, 1860–1875...	11.44
Miter sill, old lock, Port Colborne, below mean level Lake Erie, 1860–1875.....	12.23
Coping, old lock, Port Colborne, above mean level Lake Erie, 1860–1875.....	8.45
Datum of Welland Canal survey above mean surface of Lake Ontario, 1860–1875.	0.05

The elevations of the mean level of Lakes Erie and Ontario for the years 1860–1875 are as follows:

	Feet.
Lake Ontario	246.61
Lake Erie	572.86

The elevations of the new miter sills at the entrance locks are:

	Feet.
Lock No. 1, Port Dalhousie 246.61 — (13.49 + 2.92)	230.20
Entrance lock, Port Colborne	557.63
Datum of Welland Canal survey is (246.61 + 0.05)	246.66

These elevations are all based on United States Lake Survey determination of Bench Mark B, or zero of gauge at Port Dalhousie, and of bench mark on custom-house at Port Colborne.

KINGSTON GAUGE COMPARISON.

The following comparison is made to establish the zero of the gauge at the Kingston dry dock relative to the zero of United States engineers' gauge at Oswego. The record at Kingston is furnished by Mr. Thomas Monro, engineer Soulanges Canal.

Month.	1891.		1892.		1893.		1894.	
	Oswego.	Kingston.	Oswego.	Kingston.	Oswego.	Kingston.	Oswego.	Kingston.
	Feet.	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*
January	2.07	1.23	0.39	—0.02	0.75	0.16	1.44	0.43
February	2.33	1.30	.36	.12	.64	.20	1.62	.67
March	2.87	1.86	.49	—.07	1.12	.28	1.92	1.06
April	3.35	2.50	1.07	.02	1.87	.61	1.97	1.28
May	3.13	2.43	1.13	.28	3.03	1.50	2.15	1.38
June	2.71	1.94	1.69	.84	3.25	2.34	2.68	1.77
July	2.43	1.75	2.20	1.47	2.99	2.26	2.48	1.66
August	1.99	1.32	2.12	1.39	2.45	1.64	1.90	1.17
September	1.56	.93	1.92	1.13	2.18	1.30	1.39	.59
October	.92	.17	1.48	.62	1.66	1.10	1.14	.35
November	.32	—.19	1.21	.40	1.25	.85	.81	.14
December	.29	—.36	1.08	.27	1.10	.33	.46	—.25
Mean	2.00	1.24	1.26	0.54	1.86	1.05	1.66	0.85
Difference	0.76		0.72		0.81		0.81	

Mean of the four years, 0.77 ft.

As the elevation of the zero of the Oswego gauges is 244.21 feet, the elevation of the zero of the Kingston gauge is 244.21 + 0.77, or 244.98 feet.

PART III.—NOTABLE ELEVATIONS—PLANES OF REFERENCE AND BENCH MARKS.

The following elevations have been used in the work of the Commission, and are assembled for convenient reference, as they are the principal planes for reference in considering questions pertaining to the Great Lakes and the St. Lawrence and Hudson rivers.

The plane to which all elevations are referred is that adopted by the Lake Survey, and corresponds to an elevation of 14.73 feet above mean tide at New York for the bench mark on the gristmill at Greenbush, N. Y.

This plane is 1.08 feet above average sea level at New York, by the last determination of the Greenbush bench mark by the Coast and Geodetic Survey, 1.03 feet above average Gulf level (preliminary value) as determined at Chicago from the level of the Mississippi River Commission, and 0.89 foot above mean Gulf level as determined at Duluth.

LAKE SUPERIOR.

	Elevation.
	Feet.
Standard low water	600. 69
Standard high water (Lake Survey plane of reference for water levels)	604 76
Mean lake level, 1860–1895	601. 09
Mean lake level, 1871–1895	601. 57
Plane of reference for harbor improvements; low-water datum, 25.53 feet below bench mark No. 1 at Duluth	601. 19
Duluth and Superior City datum (same as low-water datum)	601. 19
Bench marks:	
No. 1. Duluth (by Lake Survey levels)	626. 72
No. 1. Marquette (1871), southeast corner of the top of the foundation stone of Grace furnace	609. 93
No. 2. Marquette (1874), cross on the window sill of the Marquette city waterworks, north side center window, west side of building	609. 43

ST. MARYS RIVER.

Standard low water:	
Above the locks	600. 05
Below the locks	581. 68
Mean surface, 1871–1895:	
Above the locks	600. 95
Below the locks	583. 27
Standard high water:	
Above the locks	604. 18
Below the locks	586. 71
Plane of reference for water levels:	
Above the locks	604. 18
Below the locks	—0. 58
United States canal datum (120 feet below bench mark 2 at Sault Ste. Marie)	485. 29
Plane of reference for United States Channel Improvements, selected so as to give 20 or 21 feet navigation at a mean stage of water:	
20 feet in Hay Lake Channel, water at the locks	583. 79
21 feet in channel improvements, water above locks	601. 29

ST. MARY'S CANAL.

	Upper sill.	Lower sill.	Platform.	Floor.
	Feet.	*Feet.*	*Feet.*	*Feet.*
American lock, 1881	583. 96	566. 96	567. 46	565. 79
American lock, 1897	577. 79	561. 42	561. 79	560. 29
Canadian lock, 1895	576. 54	561. 37	.....	561. 54

Bench marks:	*Feet.*
No. 1. Sault Ste. Marie (1867), a cross on stone near Indian agency	588. 62
No. 2. Sault Ste. Marie, on the coping of the south wall of the guard gates of St. Marys Canal	605. 29

The coping of the Canadian lock is the same as that of the American lock, viz, 605.29 feet.

LAKES MICHIGAN AND HURON.

	Elevation.
	Feet.
Standard low water	579. 60
Standard high water (Lake Survey plane of reference for water levels; observed high water of 1838)	584. 34
Mean lake level:	
1860–1875	581. 28
1860–1895	581. 26
1871–1895	581. 20
Plane of reference for Harbor Improvements:	
For Chicago and Calumet (plane 1 foot above Chicago city datum)	580. 60
Harbors on west side of lake (plane 4 feet below high water, 1838)	580. 34
Harbors on east side of lake (plane 3.06 feet below high water 1838, or mean lake level, 1860–1875)	581. 28
Chicago city datum (low water of 1847; see Part II)	579. 60
Illinois and Michigan Canal, and Chicago Sanitary and Ship Canal datum. (See Part II)	579. 55
Milwaukee city datum (low water of March, 1836)	580. 34
Bench marks:	
United States bench mark No. 99, Chicago (11,622 above Chicago city datum)	591. 22
Bench mark No. 1, on Dr. I. A. Lapham's house at Milwaukee (now destroyed)	592. 67
Bench mark No. 5 (1876), Kilbourn gristmill, Milwaukee	590. 19
Bench mark No. 2 (1875), cross on stone at Lakeport, Lake Huron	590. 86
Bench mark No. 1 (1874), at Escanaba, Lake Michigan	593. 01
Bench mark (1873) at Port Austin, Lake Huron	590. 53

ST. CLAIR RIVER.

Plane of reference for channel improvements, selected so as to give 21 feet in channel at foot of Lake Huron.

The corresponding stage in Lake Huron is 581.17 feet.

The standard high and low water of the St. Clair River at Port Huron is obtained by deducting 1.33 feet (estimated value) from the elevations determined for Lake Huron.

LAKE ST. CLAIR.

	Elevation.
	Feet.
Standard low water (deduced from Detroit River)	574.26
Standard high water (deduced from Detroit River)	578.04
Mean lake level, 1871–1895 (deduced from Detroit River)	575.75
Plane of reference for channel improvements corrresponds to a stage of water in Lake St. Clair at an elevation of	575.44

DETROIT RIVER.

Standard low water (foot of Mount Elliott avenue, Detroit)	573.84
High water (Lake Survey plane of reference for water levels)	577.62
Mean level, 1860–1895 (foot Mount Elliott avenue) deduced from Lake Erie	575.42
Mean level, 1871–1895 (foot Mount Elliott avenue) deduced from Lake Erie	575.34
Plane of reference for channel improvements is the equivalent of water levels in Lake Erie at the following elevations:	
Limekiln Crossing, 20 feet depth (Lake Erie surface)	572.06
Mouth of river, 21 feet depth (Lake Erie surface)	572.58
Bench marks:	
United States bench mark, Detroit, 1871, at Detroit, on new light-house depot	584.78
United States bench mark, Detroit Junction (1877), Detroit, on Michigan Central Railroad shop	592.68
Detroit city datum	480.30

LAKE ERIE.

Standard low water	571.35
Standard high water (Lake Survey plane of reference for water levels)	575.20
Mean lake level:	
1860–1875	572.86
1860–1895	572.88
1871–1895	572.79
Plane of reference for harbor improvements, mean lake level, 1860–1875	572.86
Cleveland city datum (observed high water of 1838)	575.20
Welland Canal, upper miter sill, entrance lock, Port Colborne	557.63
Erie Canal, upper miter sill, guard lock, Black Rock	560.96
Bench marks:	
Bench mark 2 (1875), at Gibraltar, on doorsill of light-house	584.97
Bench mark on custom-house (1875), stone foundation of custom-house, Port Colborne	584.64
Bench mark at Buffalo, on light-house	589.81
Bench mark at Cleveland, on top of wall of Ohio Canal, lock at junction canal and river	581.50
Bench mark 1 (1873), Erie, Pa., on top of stone post	575.60

NIAGARA RIVER.

Plane of reference for channel and harbor improvements below Ship-lock at Black Rock is taken as 1.04 feet above standard low water as estimated for the Niagara River, and is the equivalent of mean water (1860–1875) for Lake Erie.

LAKE ONTARIO.

	Elevation.
	Feet.
Standard low water	244.53
Standard high water (mean for May, 1870)	249.04
Lake Survey plane of reference for water levels:	
Mean lake level—	
1860–1875	246.61
1860–1895	246.48
1871–1895	246.26
Plane of reference, United States harbor improvements, the zero of engineer's gauge at Oswego	244.21
Plane of reference for Canadian harbor improvements, taken as the zero of Toronto harbor commissioners' gauge (see water levels for the Great Lakes, etc.) *a*	245.40
Datum used in Welland Canal construction, 13.54 feet on miter sill, old lock, Port Dalhousie	246.66
Lower miter sill, Lock 18, Erie Canal at Oswego	237.07
Lower miter sill, entrance lock, Welland Canal at Port Dalhousie	230.20
Lower miter sill, entrance lock, Rideau Canal, Kingston (approximate)	237.81
Bench marks:	
Bench mark A, Oswego	251.96
Bench mark at Charlotte, on light-house	283.23
Bench mark B, Port Dalhousie, same as zero of gauge	258.05
Bench mark 1 (1874), Sacketts Harbor, N. Y.	252.02

a In a letter dated September 2, 1896, Mr. Thomas Monro gives the elevation of the zero of this gauge as 245.36 deduced from a comparison of sixteen years, 1860–1875.

ST. LAWRENCE RIVER.

Standard low and high water and the miter sills for the several points between Lakes Ontario and Montreal are as follows:

	Standard low water.	Standard high water.	Plane of reference.
	Feet.	*Feet.*	*Feet.*
Ogdensburg, N. Y.	244.28	248.57	*a* 245.33
Galops Canal:			
Old lock 27	243.46	247.82	*b* 235.15
Old lock 25	228.01	234.19	*b* 218.52
Rapide Plat Canal:			
Old lock 24	224.51	.....	*b* 217.33
Old lock 23	212.81	218.40	*b* 205.82
Farrans Point Canal, old lock 22	201.72	204.60	*b* 193.77
Cornwall Canal:			
Old lock 21	201.13	.....	*b* 192.53
New lock 15	153.99	157.28	*b* 139.28
Valleyfield, Province of Quebec, lock 14	153.50	155.94	*b* 142.52
Melocheville, lock 6	70.00	.....	*b* 60.83
Lachine, old lock 5	67.80	.....	*b* 58.39
Montreal, old lock 1	23.10	35.78	*b* 7.10

a Zero of gauge. *b* Miter sill.

The standard planes are also referred to the following points:

	Reading, standard low water.	Plane of reference.
Lake Ontario, Kingston, sill of Graving Dock	15.33	229.20
Galops Canal, upper entrance, new sill	14.75	228.71
Rapide Plat Canal:		
Upper entrance, new sill	15.18	209.83
Lower entrance, new sill	15.93	196.88
Cornwall Canal, upper entrance, new sill	15.02	186.11
Soulanges Canal:		
Upper entrance, new sill	16.18	137.32
Lower entrance, new sill	16.18	53.82
Lachine Canal, upper entrance, new sill	14.46	53.34

Plane of reference for channel and harbor improvements near Ogdensburg is taken as the zero of the Ogdensburg gauge. The elevation is 245.33 feet.

Plane of reference from Ogdensburg to Montreal is taken as the miter sills of the several locks.

Plane of reference used by the harbor commissioners at Montreal is the water surface having a depth of 16.33 feet on the miter sill of old Lock No. 1.

Plane of reference or low water at Quebec has been determined by Mr. R. Steckel, C. E., and the following elevations are given:

	Feet.
Low water	— 6.11
Zero of harbor commissioners' gauge at Levis Graving dock	—13.06

LAKE CHAMPLAIN.

	Elevation.
	Feet.
Standard low water	95.03
Standard high water (May 4, 1869)	103.78
Mean lake level (1871–1895)	97.20
Mean lake level (1871–1882), by Coast and Geodetic Survey	97.17
Plane of reference of harbor improvements; low water taken as the zero of the engineer's gauge at Fort Montgomery	94.53

LAKE CHAMPLAIN AND RICHELIEU RIVER.

International bench mark on Chapman Block, Rouses Point	110.06
Lower miter sill, Lock No. 23, Champlain Canal (Coast and Geodetic Survey) at Whitehall	85.92
Upper miter sill, Lock No. 1, Chambly Canal	87.41
Coping, Lock No. 1, Chambly Canal	102.64
Lower miter sill, Lock No. 9, Chambly Canal at Chambly Basin	13.58
Lower miter sill of St. Ours Lock, Richelieu River	8.22
Coping, St. Ours Lock, Richelieu River	33.68

HUDSON RIVER.

Standard low water, mean low tide, Albany basin	1.30
Erie Canal datum, mean low water	1.30
Miter sill of Lock No. 1 at Albany	—6.145
Bench mark on gristmill at Greenbush, N. Y.	14.728

PART IV.—REFERENCE PLANES AND DEPTHS FOR HARBOR AND CHANNEL IMPROVEMENTS.

The following notes give the planes of reference to which depths are referred in the improvements of the harbors and channels of the Great Lakes, the St. Lawrence and the Hudson rivers; the depths of the several harbors and channels below these reference planes, and also the depths referred to standard low water.

The relative depth available in harbors and channels is properly expressed at standard low water, as this is so deduced as to have an equivalent value for all the bodies of water considered.

It will be seen that there are diverse planes of reference in use, some lakes having as many as three, or a separate plane for each harbor district, while main ship channels are variously referred in different localities.

These notes are made up from the latest official reports. The depths given have not been secured in all cases, but represent the adopted project in accordance with which work has been or is being carried on.

LAKE SUPERIOR.

United States harbors.

[Plane of reference, low water datum, 3.57 feet below Lake Survey plane of reference, or assumed high water of 1838.]

	Depth below plane of reference.	Depth below standard low water.
	Feet.	*Feet.*
Duluth, Minn	16	15.50
Superior Bay, Minn	16	15.50
Agate Bay, Minn	(a)	.....
Grand Marais, Minn	16	15.50
Ashland, Wis	17	16.50
Ontonagon, Mich	12	11.50
Eagle Harbor, Mich	14	13.50
Marquette, Mich	b 15	14.50
Grand Marais (harbor of refuge)	b 15½	15
Waterway from Keweenaw Bay to Lake Superior, Mich	16	15.5

a Ample depth. b Approximate.

Canadian harbors.

[Plane of reference, taken the same as for the United States harbors.]

Port Arthur, Ontario	16	15.5
Kaministiquia River, Ontario	16	15.5

LAKES MICHIGAN AND HURON.

United States harbors.

[Plane of reference, mean lake level (1860–1875), 3.06 feet below high water, 1838, as observed at Milwaukee.]

Black River, Port Huron	16	14.32
Sand Beach (harbor of refuge)	21	19.32
Cheboygan, Mich	18	16.32
Charlevoix, Mich	12	10.32
Frankfort, Mich	12	10.32
Manistee, Mich	15	13.32
Ludington, Mich	13	11.32
Pentwater, Mich	12	10.32
White Lake, Mich	12	10.32
Muskegon, Mich	14	12.32
Holland, Mich	12	10.32
Saugatuck, Mich	12	10.32
South Haven, Mich	12	10.32
St. Joseph, Mich	16	14.32
Grand Haven, Mich	19–14	17.32–12.32
Michigan City, Ind. (inner harbor)	a 13	11.32
Alpena, Mich	16	14.32
Saginaw River, Bay City, Mich	14	12.32
Saginaw River, Bay City to Saginaw, Mich	12	10.32
Ausable, Mich	10	8.32
Petoskey, Mich	a 12.5	10.82
Portage Lake (harbor of refuge), Mich	18	16.32

[Plane of reference, Milwaukee city datum, or 4 feet below high water of 1838, as observed at Milwaukee.]

Milwaukee, Wis	18	17.26
Racine, Wis	16	15.26
Greenbay, Wis	16	15.26
Menominee, Wis. and Mich	16	15.26
Sheboygan, Wis	a 18–14	17.26–13.26
Manitowoc, Wis	a 18–14	17.26–13.26
Kenosha, Wis	15	14.26
Kewaunee, Wis	14	13.26
Cedar River, Mich	14	13.26
Sturgeon Bay and Lake Michigan Canal, Wis	13	12.26
Harbor of Refuge, Wis	a 16	15.26

a Approximate.

LAKES MICHIGAN AND HURON—Continued.

United States harbors—Continued.

[Plane of reference, Milwaukee city datum, or 4 feet below high water of 1838, as observed at Milwaukee.]

	Depth below plane of reference.	Depth below standard low water.
	Feet.	*Feet.*
Manistique, Mich	12	11.26
Ahnapee, Wis	12	11.26
Two Rivers, Wis	12	11.26
Port Washington, Wis	12	11.26
Waukegan, Ill	12	11.26
Pensaukee, Wis	10	9.26
Oconto, Wis	8	7.26

[Plane of reference, 1 foot above Chicago city datum, or 3.74 feet below high water of 1838, as observed at Milwaukee.]

Chicago, Ill	16	15

The harbor of refuge has a depth of from 18 to 32 feet, the greatest part of the outer harbor 16 feet, and river entrance 18 feet.

The Chicago River or harbor proper is maintained by the city and the limiting depth is determined by the crown of the three tunnels, which are given by the assistant city engineer as follows:

	Below plane of reference.	Below standard low water.
	Feet.	*Feet.*
Main River, La Salle street at center	18.5	17.5
South branch, Washington street	18	17
South branch, Van Buren street	19	18
Calumet, Ill	16	15

Canadian harbors.

[Plane of reference, low water, taken as equivalent to 14 feet on miter still of Entrance Lock at Port Colborne, Lake Erie, or 0.28 foot above standard low water.]

	Depth below plane of reference.	Depth below standard low water.
	Feet.	*Feet.*
Meaford	14	13.72
Port Albert		
Thornbury	14	13.72
Owen Sound, Georgian Bay	16	15.72
Collingwood, Georgian Bay	16	15.72
Goderich, Georgian Bay	18	17.72
Clapperton, North Channel	18	17.72
Little Current, North Channel	13	12.72
Mt. Innis Bank	13	12.72
Southampton		
Kincardine		
Port Elgin		
Lions Head		
Midland	10	9.72
Penetanguishene	15	14.72
Dyers Bay		

LAKE ERIE.

United States harbors.

[Plane of reference, mean lake level (1860–1875), or 2.34 feet below high water 1838.]

	Depth below plane of reference.	Depth below standard low water.
	Feet.	*Feet.*
Cleveland, Ohio	a 16	14.49
Toledo, Ohio	17	15.49
Sandusky, Ohio	17	15.49
Ashtabula, Ohio	a 20	18.49
Huron, Ohio	a 17	15.49
Black River, Ohio	a 18	16.49
Fairport, Ohio	a 18–15	16.49–13.49
Conneaut, Ohio	a 17–11	15.49– 9.49
Port Clinton, Ohio	10	8.49
Monroe, Mich	10	8.49
Vermillion, Ohio	12	10.49
Sandusky River, Ohio	9	7.49
Erie, Pa	18	16.49
Dunkirk, N. Y	13	11.49
Buffalo, N. Y	a 19	17.49

a Approximate.

Canadian harbors.

[Plane of reference, low water, taken as 14 feet on miter sill of entrance lock at Port Colborne, or 0.28 foot above standard low water.]

Kingsville	12	11.72
Port Rowan	.....	.....
Port Stanley	12	11.72
Port Dover	.....	.....
Port Maitland	.....	.....
Rondeau (harbor of refuge)	.....	.....

LAKE ONTARIO.

United States harbors.

[Plane of reference, extreme low water, taken as the zero of engineer's gauge at Oswego.]

Oswego, N. Y	15	15.32
Charlotte, N. Y	16	16.32
Sacketts Harbor, N. Y	10	10.32
Little Sodus Bay, N. Y	15	15.32
Great Sodus Bay, N. Y	16	16.32
Pultneyville, N. Y	10	10.32

[Plane of reference, mean lake level (probably from 1860–1875), or 2.43 feet below Lake Survey plane of reference.]

Wilson, N. Y	12	9.92
Olcott, N. Y	13½	11.42
Oak Orchard, N. Y	13½	11.42

Canadian harbors.

[Plane of reference, low water, taken as zero of harbor commissioner's gauge at Toronto. This plane may not be absolutely correct for the entire lake, but is taken as approximately correct.]

Trenton	10	9.13
Toronto	16	15.13
Kingston Graving Dock	16	15.13
Kingston	a 11	10.13
Bowmanville	14	13.13
Newcastle	14	13.13
Port Hope	12	11.13
Napanee	10	9.13
Belleville	11	10.13
Cobourg	12	11.13

a Approximate.

LAKE ONTARIO—Continued.

Canadian harbors—Continued.

[Plane of reference, low water, taken as zero of harbor commissioner's gauge at Toronto. This plane may not be absolutely correct for the entire lake, but is taken as approximately correct.]

	Depth below plane of reference.	Depth below standard low water.
	Feet.	*Feet.*
Northport	9	8.13
Bath	7	6.13
Wolfe Island, head St. Lawrence River	8	7.13
Gananoque, St. Lawrence River	12	11.13
Picton	10	9.13
Port Credit	10	9.13
Whitby	12	11.13
Hamilton or Burlington Bay Channel	14	13.13
Pickering	11	10.13
Oakville	12	11.13

LAKE CHAMPLAIN.

[Plane of reference, extreme low water, taken as the zero of United States Engineers' gauge at Fort Montgomery.]

Plattsburg, N. Y	8	8.50
Great Chazy River, N. Y	5	5.50
Ticonderoga, N. Y	8	8.50
Burlington, Vt	8	8.50
Otter Creek, N. Y	8	8.50
Narrows of Lake Champlain, New York and Vermont	12	12.50

CHANNEL IMPROVEMENTS.

ST. MARYS RIVER.

	Elevation of plane of reference.	Depth below plane of reference.	Depth below standard low water.
	Feet.	*Feet.*	*Feet.*
Above the locks	601.29	21	19.76
New Hay Lake Channel	583.79	20	17.89

ST. CLAIR RIVER.

At foot of Lake Huron	581.17	21	19.43
Belle River, Marine City, Mich. (harbor)	.....	10	8.67
Pine River at St. Clair, Mich. (harbor)	.....	10	8.67

LAKE ST. CLAIR.

Ship channel and canal	575.44	20	18.82
Clinton River, Mich. (harbor)	.....	10	8.82

DETROIT RIVER.

Limekiln Crossing	572.08	20	19.27
At mouth of river	572.58	21	19.77

CANADIAN HARBORS.

[Plane of reference, same as by the United States at Limekilns.]

Anderson	.....	12	11.27
Amherstburg	.....	16	15.27

NIAGARA RIVER.

[Plane of reference, taken as 1.04 feet above the estimated plane of standard low water.]

Buffalo to Tonawanda	.....	18	16.96
Tonawanda to Port Day	.....	12	10.96
Tonawanda Harbor	565.16	16–18	14.96–16.96

UPPER ST. LAWRENCE.

[Plane of reference taken as the zero of the Ogdensburg gauge.]

	Elevation of plane of reference.	Depth below plane of reference.	Depth below standard low water.
	Feet.	*Feet.*	*Feet.*
Channel, Lake Ontario to Ogdensburg	.....	18	16.95
Ogdensburg Harbor, New York	.....	16.5	15.45
Waddington Harbor, New York	.....	12	10.95

CANADIAN HARBORS.

[Plane of reference, low water, estimated as 1.50 feet below standard low water.]

Chateaugay Basin, Lake St. Louis	.....	8	9.50
Dorval	.....	7	8.50

LOWER ST. LAWRENCE.

[Plane of reference, low water, 16.33 feet on miter sill of old lock No. 1, Montreal.]

The harbor improvements at Montreal appear to have lowered the water about 1 foot with respect to the stage below, or the present equivalent of 16.33 feet on the gauge is about 15.33 feet.

	Depth below plane of reference.	Depth below standard low water.
	Feet.	*Feet.*
Montreal Harbor	27.50	27.17
Channel improvement, St. Peters Flats	27.50	*a* 27.17

a Approximate.

HUDSON RIVER.

[Plane of reference, mean low tide, or standard low water elevation is 1.30 feet at Albany. Channel improvements, from Troy Dam to Hudson City, 12 feet below standard low water.]

Canals.	Depths.		Dimension of lock.
	Nominal.	At standard low water.	
	Feet.	*Feet.*	*Feet.*
Sault Ste. Marie:			
American, 1881	16	14.22	515 by 80
American, 1897	21	19.89	800 by 100
Canadian, 1895	21	20.14	900 by 60
Welland:			
Port Colborne	14	13.72	270 by 45
Port Dalhousie	14	14.33	
St. Lawrence canals:			
Galops	*a* 14	14.75	270 by 45
Rapide Plat	*a* 14	15.18 / 15.93	270 by 45
Cornwall	14	15.02 / 14.71	270 by 45
Soulanges	14	16.18 / 16.18	270 by 45
Lachine	14	14.46 / 17.93	270 by 45
Erie and Oswego	7	.....	110 and 220 by 18
Champlain	6	.....	110 by 18
Chambly	7	.....	118–125 by 22.5–24
St. Ours Lock	7	.....	200 by 45
Rideau-Trent, navigation	5	.....	134 by 33

Lower Ottawa navigation, from Ottawa to Lachine, comprising the Greenville and Carillon canals, and St. Annes Lock. Depth, 9 feet; dimensions of locks, 200 by 45 feet.

a Present depth 9 feet, but enlargement to 14 feet in progress.

EXHIBIT B 2.

WATER LEVELS FOR THE GREAT LAKES AND ST. LAWRENCE RIVER FOR THE YEARS 1860 TO 1895, INCLUSIVE.[1]

Notes by ALEX. E. KASTL, C. E.

NOTES TO ACCOMPANY TABLES AND DIAGRAMS.

Table No. 1—Lake Michigan at Milwaukee, Wis., 1860–1895.
Table No. 2—Lake Huron at Point Aux Barques, Port Austin, and Sand Beach, Mich., 1860–1895.
Table No. 3—Lake Superior at Superior, Wis., and Marquette, Mich., 1860–1895.
Table No. 4—St. Marys River at Sault Ste. Marie, Mich., above the locks, 1871–1895.
Table No. 5—St. Marys River at Sault Ste. Marie, Mich., below the locks, 1871–1895.
Table No. 6—Detroit River at Light-house Depot, Detroit, Mich., 1867–1881.
Table No. 7—Lake Erie at Cleveland, Ohio, 1860–1895.
Table No. 8—Lake Erie at Erie, Pa., 1860–1895.
Table No. 9—Lake Ontario at Oswego, N. Y., 1860–1895.
Table No. 10—Lake Ontario at Charlotte, N. Y., 1860–1895.
Table No. 11—St. Lawrence River at Valleyfield, Province of Quebec, 1860–1895.
Table No. 12—St. Lawrence River at Montreal, Province of Quebec, 1860–1895.
Table No. 13—Lake Champlain at Fort Montgomery, N. Y., 1871–1895.
Table No. 13*a*—River Richelieu at St. Johns, Province of Quebec, 1863–1870.
Table No. 14—St. Lawrence River at Montreal, Province of Quebec, 1860–1895.
Table No. 15—St. Lawrence River from Prescott to Montreal, provinces of Ontario and Quebec, for the years 1870 and 1895.
Supplemental table—Water record for 1896.
Diagrams No. 1 and No. 1*a*—Water levels for the Great Lakes and St. Lawrence River.
Diagram No. 2—Water levels and slopes—rivers connecting the lakes.
Diagram No. 3—Mean annual variation.
Diagram No. 4—Variation of annual means.

INTRODUCTION.

The following notes have been prepared to accompany the "Tables of water levels for the Great Lakes and St. Lawrence River," numbered from 1 to 15, and the diagrams in illustration of the same.

The tables are compiled from official sources. Every effort has been made to make the record complete and reliable for the period of thirty-six years, from 1860 to 1895, inclusive, and to make sure that no errors have been introduced in the planes of reference. The notes give the authority for all data used.

The tables are based on the monthly mean readings. The yearly means, the means of the months for the thirty-six years, 1860 to 1895,

[1] By Assistant Alex. E. Kastl, under the direction of L. E. Cooley, C. E., for the United States Deep Waterways Commission.

and for twenty-five years, 1871 to 1895, and the mean level for each period, are given. Certain deductions are made in regard to standard high water and standard low water, for the purpose of furnishing equivalent water planes throughout the lakes and St. Lawrence for the several profiles. The characteristic elements in the fluctuations of the period are also noted.

All elevations given herein depend on the bench mark at Greenbush, N. Y., as determined by the Coast and Geodetic Survey and adopted by the Lake Survey in 1880. The elevation of this bench mark is taken at 14.73 feet above mean tide at New York City.

The diagrams are designed to repeat the record graphically and show the annual fluctuations, the fluctuations in yearly means, and the curves of monthly means. A special diagram is compiled to show the variation in slope through the St. Marys River between Lake Superior and Lake Huron, and through the St. Clair and Detroit rivers between Lake Huron and Lake Erie.

The water levels from 1860 to 1871, for the several lakes, as kept by the United States Lake Survey, are not considered as reliable as those of subsequent years. The report of the Chief of Engineers, U. S. A., for 1876 states:

> Between 1860 and 1871 but little attention was paid to the checking of zeros and bench marks. Since 1871 it has been carefully attended to and levels run each year.

The twenty-five year means cover the most authentic part of the record.

LAKE MICHIGAN (TABLE NO. 1).

The data for the table of monthly means of water levels for Lake Michigan at Milwaukee, Wis., were obtained as follows: From January, 1860, to June, 1894, from the annual reports of the Chief of Engineers, U. S. A., 1876 to 1894, inclusive; from July, 1894, to December, 1895, from manuscript furnished by Capt. George A. Zinn, Corps of Engineers, U. S. A., at Milwaukee, Wis. The table has been checked with the original record in the office of Captain Zinn.

The plane of reference for the water levels is that adopted by the United States Lake Survey in 1876, and is the plane of the high water of July, 1838, as observed at Milwaukee. This plane of reference is 4 eet above the Milwaukee city datum, which is the low water of March, 1836. According to the United States Lake Survey,[1] the plane of reference is 8.33 feet below the old bench mark (now destroyed) on Dr. I. A. Lapham's house. The elevation of this bench mark was 592.67 feet[2] above mean tide at New York City. The elevation of the plane of reference is, therefore, 592.67 — 8.33, or 584.34 feet above mean tide at New York City. The plane of reference has been referred to a number of other bench marks in Milwaukee, which may be found in the reports of the Chief of Engineers, U. S. A., 1876 and 1877.

The plane of standard high water for Lake Michigan has been taken as the high water of July, 1838, that being the highest of which there is any record. Its elevation is 584.34 feet above mean tide at New York City.

The plane of standard low water for Lake Michigan has been taken as the mean of the monthly mean water levels during the season of navigation in the year 1847, as observed at Milwaukee by Dr. I. A. Lapham. The following is the record.

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[1] See Report of Chief of Engineers, U. S. A., 1876, part 3, pages 83 and 84.

[2] See Final Report of United States Lake Survey, Professional Papers, Corps of Engineers, U. S. A., No. 24, page 617.

Milwaukee monthly means of water levels below the plane of reference or high water of July, 1838, from April to November, 1847, inclusive.

Month.	Feet.	Month.	Feet.
April	5.19	September	4.45
May	4.98	October	4.77
June	4.57	November	4.88
July	4.51		
August	4.56	Mean	4.74

The elevation of the plane of standard low water is, therefore, 584.34—4.74, or 579.60 feet above mean tide at New York City. This plane is 0.74 feet below Milwaukee city datum, and is the same as Chicago city datum and the datum of the Illinois and Michigan Canal and of the Chicago Sanitary and Ship Canal.[1]

An examination of the table of monthly mean of water levels shows that during the period of thirty-six years, from 1860 to 1895, monthly mean water has stood at or below this plane an aggregate of eighteen months, counting all the months of every year; or an aggregate of ten months, counting the months of the season of navigation, which excludes the months of January, February, and March of every year. This statement is equally true for the period of twenty-five years, 1871 to 1895. The following is the record:

Milwaukee monthly means of water levels at or below a plane 4.74 feet below the plane of reference or high water of July, 1838, during the period 1860 to 1895.

Year.	Month.	Reading.	Year.	Month.	Reading.
		Feet.			*Feet.*
1872	December	4.82	1895	January	4.82
1873	January	4.82	1895	February	4.93
1873	February	4.78	1895	March	4.96
1891	November	4.93	1895	April	4.76
1891	December	4.99	1895	August	4.78
1892	January	4.87	1895	September	5.05
1892	March	4.78	1895	October	5.42
1892	December	4.74	1895	November	5.64
1893	January	4.75	1895	December	5.75

The number of months is 18. The number of months, excluding January, February, and March, is 10.

The above record has been prepared with a view of determining equivalent standard low-water planes for the other lakes.

The mean surface of Lake Michigan for the period of thirty-six years from 1860 to 1895 is 3.08 feet below the plane of reference, or 581.26 feet above mean tide at New York City; for the period of twenty-five years from 1871 to 1895 it is 3.14 feet below the plane of reference, or 581.20 feet above mean tide at New York City. The mean surface as determined by the United States Lake Survey for the period of sixteen years from 1860 to 1875, is 581.28 feet above mean tide at New York City, and this is the generally accepted value.

As regards annual variation, the lake is generally highest in the month of July and lowest in the month of December.

[1] It is found that canal datum differs slightly from the above. See Part II, "Elevations for the Great Lakes," etc.—L. E. C.

An examination of the record for the period of thirty-six years from 1860 to 1895 develops the following:

	Feet.
Range in mean annual variation	0.98
Mean annual range	1.32
Greatest annual range (in 1871)	2.23
Least annual range (in 1877)	.57
Highest monthly mean water, June, 1886 (below plane of reference)	1.16
Lowest monthly mean water, December, 1895 (below plane of reference)	5.75
Greatest range in monthly mean waters	4.59
Highest annual mean water, 1886 (below plane of reference)	1.77
Lowest annual mean water, 1895 (below plane of reference)	4.99
Greatest range in annual mean waters	3.22

LAKE HURON (TABLE NO. 2).

The data for the table of monthly means of water levels for Lake Huron were obtained as follows: From January, 1860, to June, 1894, from the annual reports of the Chief of Engineers, U. S. A., 1876 to 1894, inclusive; from July, 1894, to December, 1895, from table furnished by Lieut. J. B. Cavanaugh, Corps of Engineers, U. S. A., at Detroit, Mich. The table has been checked with the manuscript table for the period since 1871, and the discrepancies compared with the original record by Lieutenant Cavanaugh. A change has been made in the record of one month as published in the annual reports.

For reasons given in the final report, of the United States Lake Survey,[1] Lake Huron is assumed to be at the same level as Lake Michigan.

Therefore the planes adopted are the same as those for Lake Michigan. They are as follows:

Plane of reference, high water of July, 1838, 584.34 feet above mean tide at New York City. This is also the plane of standard high water. Standard low water, 579.60 feet above mean tide at New York City.

For the same reasons the mean surfaces of Lake Huron for different periods are assumed to be the same as those of Lake Michigan for the corresponding periods. They are as follows:

For the period of thirty-six years, 1860 to 1895, 581.26 feet above mean tide at New York City.

For the period of twenty-five years, 1871 to 1895, 581.20 feet above mean tide at New York City.

For the period of sixteen years, 1860 to 1875, as determined by the United States Lake Survey, 581.28 feet above mean tide at New York City.

As the plane of reference was transferred from Milwaukee on Lake Michigan to the stations, Point Aux Barques and Port Austin, Mich., on Lake Huron, and from Port Austin to Sand Beach, Mich., on Lake Huron, on the assumption that the lakes are level,[2] the Lake Huron table of water levels simply serves as a check on the Lake Michigan table.

For the period of twenty-five years, 1871 to 1895, it will be seen that the mean of the annual means is the same as that for Lake Michigan. For the period of thirty-six years, 1860 to 1895, the mean of the annual means differs by only 0.01 foot from that of Lake Michigan. It should be noted that from 1865 to 1870, inclusive, there was no record kept on Lake Huron, and for these years the Lake Michigan record was used.

[1] See Professional Papers, Corps of Engineers, U. S. A., No. 24, pages 607 and 608.
[2] See Reports Chief of Engineers, 1876 and 1892.

LAKE SUPERIOR (TABLE NO. 3).

The data for the table of monthly means of water levels for Lake Superior at Superior, Wis., and Marquette, Mich., were obtained as follows: From January, 1860, to June, 1894, from the annual reports of the Chief of Engineers, U. S. A., 1876 to 1894, inclusive; from July, 1894, to December, 1895, from manuscript furnished by Maj. Clinton B. Sears, Corps of Engineers, U. S. A., at Duluth, Minn. The table has been checked with the original record in the office of Major Sears, and the record from July, 1882, to June, 1894, has been revised and is not the same as printed in the annual reports.

The plane of reference for the water levels is that adopted by the United States Lake Survey in 1876, and is the plane of an assumed high water of 1838 found by comparing Lake Michigan and Lake Superior water levels during the months of June, July, and August, 1874, and assuming that high water of 1838 was as much above the mean level of Lake Superior during these months as it was above the mean level of Lake Michigan during the same months.[1] According to the United States Lake Survey[1] the plane of reference is 5.17 feet below bench mark (1) and 4.67 feet below bench mark 2 at Marquette, Mich. The elevation of bench mark 1 is 609.93 feet,[2] and of 2 609.43 feet above mean tide at New York City. The elevation of the plane of reference is 609.93—5.17 and 609.43—4.67, or 604.76 feet above mean tide at New York City.

The plane of standard high water for Lake Superior has been taken as the assumed high water of 1838. It is higher than any recorded high water, but a comparison of the high water of 1876 for Lake Michigan and Lake Superior with that of July, 1838, for Lake Michigan, indicates that the standard high water adopted is a fair equivalent of the actual high water of 1838. The elevation of standard high water is 604.76 feet above mean tide at New York City.

The plane of standard low water for Lake Superior is equivalent to that for Lake Michigan, and is the plane at or below which monthly mean water has stood not more than an aggregate of ten months during the season of navigation out of the aggregate of eighteen lowest monthly mean waters occurring during the period of thirty-six years, 1860 to 1895. The following is the record:

Eighteen lowest monthly means of water levels below the plane of reference of United States Lake Survey during the period 1860 to 1895.

Year.	Month.	Reading.	Year.	Month.	Reading.
		Feet.			*Feet.*
1871	February	4.45	1880	March	4.57
1871	March	4.03	1880	April	4.54
1872	March	4.08	1892	February	4.18
1872	April	4.18	1892	March	4.31
1879	May	4.31	1892	April	4.30
1879	June	4.08	1893	January	4.22
1879	December	4.12	1893	February	4.31
1880	January	4.44	1893	March	4.26
1880	February	4.48	1893	April	4.16

[1] See Report of Chief of Engineers, U. S. A., 1876, part 3, p. 85.
[2] See Final Report of the United States Lake Survey, Professional Papers, Corps of Engineers, U. S. A., No. 24, p. 617.

The following are the lowest monthly means during the season of navigation, which excludes the months of January, February, and March:

Year.	Month.	Reading.	Year.	Month.	Reading.
		Feet.			*Feet.*
1872	April	4.18	1880	April	4.54
1879	May	4.31	1892	April	4.30
1879	June	4.08	1893	April	4.16
1879	December	4.12			

The reading 4.08 of June, 1879, is the highest plane in the series. The elevation of this plane is 604.76 — 4.08, or 600.68 feet above mean tide at New York City. The elevation of the plane of standard low water has been taken as 600.69 feet, which makes it exactly 0.5 foot below plane used for harbor improvements on Lake Superior and the city datum of Duluth, Minn., and Superior, Wis.

The mean surface of Lake Superior for the period of thirty-six years, from 1860 to 1895, is 3.07 feet below the plane of reference, or 601.69 feet above mean tide at New York City; for the period of twenty-five years, from 1871 to 1895, it is 3.19 feet below the plane of reference, or 601.57 feet above mean tide at New York City. The mean surface as determined by the United States Lake Survey for the period of five years, from 1871 to 1875, is 601.78 feet above mean tide at New York City, and this is the generally accepted value.

As regards annual variation, the lake is generally highest in the month of September and lowest in the month of March.

An examination of the record for the period of thirty-six years, from 1860 to 1895, develops the following:

	Feet.
Range in mean annual variation	0.99
Mean annual range	1.18
Greatest annual range (in 1869)	2.67
Least annual range (in 1891)	0.53
Highest monthly mean water, September, 1869 (below plane of reference)	1.13
Lowest monthly mean water, March, 1880 (below plane of reference)	4.57
Greatest range in monthly mean water	3.44
Highest annual mean water, 1876 (below plane of reference)	2.26
Lowest annual mean water, 1879 (below plane of reference)	3.89
Greatest range in annual mean waters	1.63

ST. MARYS RIVER ABOVE THE LOCKS (TABLE NO. 4).

The data for the table of monthly means of water levels for the St. Marys River above the locks at Sault Ste. Marie, Mich., were obtained as follows: From January, 1871, to June, 1894, from the annual reports of the Chief of Engineers, U. S. A., 1876 to 1894, inclusive; from July, 1894, to December, 1895, inclusive, from table furnished by Lieut. J. B. Cavanaugh, Corps of Engineers, U. S. A., at Detroit, Mich.

The plane of reference for the water levels is that adopted by the United States Lake Survey, and is the plane of an assumed high water of 1838 found by comparing the Sault Ste. Marie record with the Milwaukee record during the months of June, July, and August, 1874, and assuming that high water of 1838 was as much above the mean level of the St. Marys River at Sault Ste. Marie during these months

as it was above the mean level of Lake Michigan at Milwaukee during the same months.[1] According to the United States Lake Survey,[1] the plane of reference is 1.11 feet below bench mark 2 on the coping of the south wall of the guard gates of St. Marys Canal. In the final report of the United States Lake Survey,[2] the elevation of bench mark 2 is given as 605.87 feet above mean tide at New York City. The elevation of the plane of reference would be 605.87—1.11, or 604.76 feet, which is the same as that of Lake Superior.

It appears that when the elevations of the bench marks were determined by the United States Lake Survey, no allowance was made for the slope in the St. Marys River from Lake Superior to Sault Ste. Marie. In order to get the true elevations of the bench marks and plane of reference at Sault Ste. Marie, it becomes necessary to determine the mean slope in the St. Marys River during the months of June, July, and August, 1874, when the comparison was made between Lake Superior at Marquette and St. Marys River at Sault Ste. Marie, and this mean slope has been determined as follows:

On page 3427, part 6, of the Report of the Chief of Engineers, U. S. A., for 1894, is given the elevation of the mean level of Lake Superior at Waiska Bay from June 6 to September 9, 1892, inclusive, as 601.826 feet above mean tide at New York City, the elevation of the zero of the water gauge at Waiska Bay being determined by a line of precise levels from bench mark A, the elevation of which is given as 605.872 feet. From information furnished by Maj. Clinton B. Sears, Corps of Engineers, U. S. A., the mean reading of Lake Superior below the plane of reference at Marquette for the period June 6 to September 9, 1892, inclusive, was 3.51 feet, or $604.76 - 3.51 = 601.25$ feet above mean tide at New York City. Combining the foregoing results, it appears that the mean slope in the St. Marys River from Lake Superior to above the locks at Sault Ste. Marie during the months of June, July, and August, 1874, was $601.826 - 601.25$, or 0.58 feet. Therfore it is assumed that the plane of reference of the United States Lake Survey at Sault Ste. Marie is 0.58 feet lower than that at Marquette. Now, the elevation of the plane of reference at Marquette being 604.76 feet, then the elevation of the plane of reference at Sault Ste. Marie is $604.76 - 0.58$, or 604.18 feet above mean tide. All the elevations usually given at the St. Marys Falls Canal and vicinity are corrected by the arbitrary of -0.58 feet.

The plane of standard high water for the St. Marys River above the locks at Sault Ste. Marie has been taken the same as the plane of reference. Its elevation is 604.18 feet above mean tide at New York City.

The plane of standard low water for the St. Marys River above the locks at Sault Ste. Marie is equivalent to that for Lake Michigan, and is the plane at or below which monthly mean water has stood not more than an aggregate of ten months during the season of navigation out of the aggregate of nineteen lowest monthly mean waters occurring during the period of twenty-five years, 1871 to 1895. Although the Sault Ste. Marie record does not begin until January, 1871, it was deemed safe, for the purpose of deriving standard low water, to use the record as if it began in 1860, because the Lake Superior and Lake Michigan records do not show any monthly mean waters lower than their standard low water previous to 1871. The following is the record.

[1] See Report of Chief of Engineers, U. S. A., 1876, part 3, page 85.
[2] Professional Papers, Corps of Engineers, U. S. A., No. 24, page 618.

Nineteen lowest monthly means of water levels below the plane of reference of United States Lake Survey during the period 1871 to 1895.

Year.	Month.	Reading.	Year.	Month.	Reading.
		Feet.			*Feet.*
1872	March	4.13	1888	February	4.17
	April	4.18		April	4.13
1879	February	4.34	1891	March	4.13
	March	4.58	1892	February	4.30
	April	4.45		March	4.48
	December	4.24		April	4.33
1880	January	4.43	1893	January	4.17
	February	4.47		February	4.37
	March	4.56		March	4.36
	April	4.53			

Properly, the above table should contain only eighteen months in order to make it correspond with that of Lake Michigan, but inasmuch as 4.13 would be the next reading to reject, and as there are three such readings, therefore nineteen readings make the nearest approximation.

The following are the lowest monthly means during the season of navigation which excludes the months of January, February, and March:

Year.	Month.	Reading.	Year.	Month.	Reading.
		Feet.			*Feet.*
1872	April	4.18	1880	April	4.53
1879	April	4.45	1888	April	4.13
	December	4.24	1892	April	4.33

The reading 4.13 of April, 1888, determines the plane of standard low water, and its elevation is 604.18 — 4.13, or 600.05 feet above mean tide at New York City. This plane is 16.09 feet above the upper miter sill of the American Canal lock of 1881; 22.26 feet above the upper miter sill of the American Canal lock of 1897, and 23.51 feet above the upper miter sill of the Canadian Canal lock of 1895. The depths on structures are deduced from data furnished by Lieut. J. B. Cavanaugh, Corps of Engineers, U. S. A., at Detroit, Mich., and Thomas Monro, engineer Soulanges Canal, Coteau Landing, Quebec.

The mean surface of St. Marys River above the locks at Sault Ste. Marie for the period of twenty-five years, from 1871 to 1895, is 3.23 feet below the plane of reference, or 600.95 feet above mean tide at New York City.

A table giving elevations above mean tide at New York has been compiled by the United States engineer office at Detroit, and is published in the annual reports of the Chief of Engineers, U. S. A. This table contains many minor variations from Table No. 4, most of which are within the limits of different methods of reduction. These variations are both plus and minus, and six of them exceed 0.10, the largest being 0.22. None of the results given in the foregoing discussions are affected except the mean level, which would be 3.25 feet below the plane of reference in place of 3.23 feet. No explanation for the discrepancies has been found.

ST. MARYS RIVER BELOW THE LOCKS (TABLE NO. 5).

The data for the table of monthly means of water levels for the St. Marys River below the locks at Sault Ste. Marie, Mich., were furnished by Lieut. J. B. Cavanaugh, Corps of Engineers, U. S. A., at Detroit, Mich.

This table agrees with the record as printed in the annual reports of the Chief of Engineers, U. S. A.

The plane of reference for the water levels is a plane 0.58 foot below the plane of mean tide at New York City. On the original table the plane of reference was given as mean tide at New York City, but for reasons given under the head of "St. Marys River above the locks," all elevations usually given at the St. Marys Falls Canal are corrected by an arbitrary of —0.58 foot.

The plane of standard high water for the St. Marys River below the locks at Sault Ste. Marie has been determined by taking the standard high water (high water of July, 1838) of Lake Michigan, which is 584.34 feet above mean tide at New York City, and adding thereto 2.37 feet, which was the mean slope in the St. Marys River from below the locks to Lake Huron in August, 1876, when the waters of both Lake Superior and Lake Huron were simultaneously the highest during the period, 1860 to 1895, which appears to have been the case in 1838. An examination of the tables of water levels will show that in the summer of 1876 lakes Superior, Michigan, Huron, Erie, and Ontario were all high, and such was the case in the summer of 1838. The elevation of standard high water is, therefore, 584.34 + 2.37, or 586.71 feet above mean tide at New York City.

The plane of standard low water for the St. Mary's River below the locks at Sault Ste. Marie is equivalent to that for Lake Michigan, and is the plane at or below which monthly mean water has stood not more than an aggregate of ten months during the season of navigation out of the aggregate of eighteen lowest monthly mean waters occurring during the period of twenty-five years, 1871 to 1895. The following is the record:

Eighteen lowest monthly means of water levels above a plane of reference 0.58 foot below the plane of mean tide at New York City.

Year.	Month.	Reading.	Year.	Month.	Reading.
		Feet.			*Feet.*
1891	November	582.35	1893	April	582.11
	December	582.21		May	582.26
1892	April	581.79	1894	April	582.39
	May	582.04	1895	April	582.26
	November	582.25		May	582.01
	December	581.81		June	582.28
1893	January	581.99		July	582.42
	February	582.05		November	582.03
	March	582.16		December	581.89

The following are the ten lowest monthly means during the season of navigation which excludes the months of January, February, and March:

Year.	Month.	Reading.	Year.	Month.	Reading.
		Feet.			*Feet.*
1891	December	582.21	1893	April	582.11
1892	April	581.79		May	582.26
	May	582.04	1895	May	582.01
	November	582.25		November	582.03
	December	581.81		December	581.89

The reading, 582.26, of May, 1893 (also of April, 1895), determines the plane of standard low water, and its elevation is 582.26—0.58, or 581.68

feet above mean tide at New York City. This plane is 14.22 feet above the lower platform and 14.72 feet above the lower miter sill of the American Canal lock of 1881; 19.89 feet above the lower platform and 20.26 feet above the lower miter sill of the American Canal lock of 1897, and 20.14 feet above the floor and 20.31 feet above the lower miter sill of the Canadian Canal lock of 1895. The depth on structures are deduced from data furnished by Lieut. J. B. Cavanaugh, Corps of Engineers, at Detroit, and Thomas Monro, engineer Soulanges Canal, Coteau Landing, Quebec.

The mean surface of St. Marys River below the locks at Sault Ste. Marie for the period of twenty-five years, from 1871 to 1895, is 583.85 −0.58, or 583.27 feet above mean tide at New York City.

DETROIT RIVER, AT DETROIT, MICH. (TABLE NO. 6).

The data for the table of monthly mean of water levels for the Detroit River at the light-house depot, at foot of Mount Elliott avenue, Detroit, Mich., were obtained as follows: From May, 1867, to September, 1881, from the annual reports of the Chief of Engineers, U. S. A., 1876 to 1882.

The plane of reference for the water levels is that adopted by the United States Lake Survey in 1876, and is the plane of the high water of 1838.[1] According to the United States Lake Survey,[1] this plane is 7.16 feet below the bench mark, U. S. B. M. Detroit (1871), on the new light-house depot at Detroit. The elevation of this bench mark is 584.78 feet[2] above mean tide at New York City. The elevation of this bench mark was determined by a branch line of precise levels from the main line of precise levels between Lake Erie and Lake Huron.[3] The elevation of the plane of reference is, therefore, 584.78 — 7.16, or 577.62 feet above mean tide at New York City.

The plane of standard high water of the Detroit River at the foot of Mount Elliott avenue, Detroit, has been taken as the high water of 1838. Its elevation is 577.62 feet above mean tide at New York City.

The plane of standard low water for the Detroit River at the foot of Mount Elliott avenue, Detroit, has been taken as equivalent to the standard low water for Lake Erie, and is equal to the standard low water for Lake Erie increased by the mean slope in the Detroit River from the foot of Mount Elliott avenue, Detroit, to Lake Erie during the months of June and July, 1895, when the mean level of Lake Erie was at about standard low water. The mean level of the Detroit River at foot of Mount Elliott avenue during the months of June and July, 1895, was 574.10 feet[4] above mean tide at New York City; the mean level of Lake Erie during the same period was 571.61 feet. The mean slope is, therefore, 574.10 — 571.61, or 2.49 feet, and the elevation of standard low water at Detroit is 571.35 (standard low water for Lake Erie) + 2.49, or 573.84 feet above mean tide at New York City.

Standard low water for Lake St. Clair has been determined by adding to the standard low water for the Detroit River at foot of Mount Elliott avenue the mean slope[4] in the Detroit River between the foot of Mount

[1] See Report of Chief of Engineers, U. S. A., 1872, page 1069, and 1876, part 3, page 83.

[2] See Final Report of United States Lake Survey, Professional Papers, Corps of Engineers, U. S. A., No. 24, page 616.

[3] See Report of Chief of Engineers, U. S. A., 1878, part 3, page 1409.

[4] From letter of Lieut. J. B. Cavanaugh, Corps of Engineers, U. S. A., Detroit, Mich., dated February 11, 1896.

Elliott avenue and Lake St. Clair during the months of June and July, 1895. The elevation of standard low water for Lake St. Clair is, therefore, 573.84 + 0.42, or 574.26 feet above mean tide at New York City.

The mean surface of the Detroit River at the foot of Mount Elliott avenue for the period of fifteen years from 1867 to 1881 is 2.28 feet below the plane of reference, or 575.34 feet above mean tide at New York City. The mean surface for the period of thirty-six years from 1860 to 1895 is equivalent to that of Lake Erie for the same period and is found by correcting the elevation of the mean surface of the Detroit River for fifteen years by the difference between the elevations of the mean surface of Lake Erie for the periods of thirty-six years, 1860 to 1895, and fifteen years, 1867 to 1881. The correction is + 0.08 foot. Therefore, the elevation of the mean surface of the Detroit River at foot of Mount Elliott avenue for the period of thirty-six years, 1860 to 1895, is 575.34 + 0.08, or 575.42 feet above mean tide at New York City. The mean surface for the period of twenty-five years, deduced in a similar manner, is 575.34 — 0.01, or 575.33 feet above mean tide at New York City.

LAKE ERIE (TABLES NOS. 7 AND 8).

The data for the table of monthly means of water levels for Lake Erie at Cleveland, Ohio, were obtained as follows: From January, 1860, to June, 1894, from the annual reports of the Chief of Engineers, U. S. A., 1876 to 1894, inclusive; from July, 1894, to December, 1895, from manuscript furnished by Lieut. Col. Jared A. Smith, Corps of Engineers, U. S. A., at Cleveland, Ohio. This table has been checked with the original record in the office of Lieutenant Colonel Smith, by William T. Blunt, United States assistant engineer.

The plane of reference for the water levels is that adopted by the United States Lake Survey in 1876, and is the plane of the high water of 1838 as observed at Cleveland. According to the United States Lake Survey,[1] the plane of reference is 6.30 feet below the bench mark on the top of the coping of the lock of the Ohio Canal between Merwin street and the Cuyahoga River. The elevation of this bench mark is 581.50 feet.[2] The elevation of the plane of reference is 581.50 — 6.30, or 575.20 feet above mean tide at New York City. This plane corresponds to Cleveland city datum.

The plane of standard high water for Lake Erie has been taken as the high water of 1838, that being the highest of which there is any record. Its elevation is 575.20 feet above mean tide at New York City.[3]

The plane of standard low water for Lake Erie is equivalent to that for Lake Michigan, and is the plane at or below which monthly mean water has stood not more than an aggregate of ten months during the season of navigation out of the aggregate of eighteen lowest monthly mean waters occurring during the period of thirty-six years, 1860 to 1895. The following is the record.

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[1] See Report of Chief of Engineers, U. S. A., 1876, part 3, page 82.

[2] See Final Report of the United States Lake Survey, Professional Papers, Corps of Engineers, U. S. A., No. 24, page 615.

[3] The high water of June 19, 1858, the record of which has recently come to hand (November 21), is some 0.25 foot higher than in 1838. (See "Water levels, etc., prior to 1860.")—L. E. C.

Eighteen lowest monthly means of water levels below the plane of reference of United States Lake Survey during the period 1860 to 1895.

Year.	Month.	Reading.	Year.	Month.	Reading.
		Feet.			*Feet.*
1868	February	4.07	1893	January	3.94
1872	March	3.86		February	3.86
	December	3.85	1895	January	3.88
1873	January	3.95		February	4.11
	February	3.94		March	4.10
	March	3.87		April	3.85
1891	November	3.90		October	4.31
1892	February	4.01		November	4.41
	March	3.97		December	4.25

The following are the lowest monthly means during the season of navigation, which excludes the months of January, February, and March:

Year.	Month.	Reading.	Year.	Month.	Reading.
		Feet.			*Feet.*
1872	December	3.85	1895	October	4.31
1891	November	3.90		November	4.41
1895	April	3.85		December	4.25

The readings 3.85 of December, 1872, and April, 1895, determine the plane of standard low water, and its elevation is 575.20 — 3.85, or 571.35 feet above mean tide at New York City. This plane is 3.85 feet below Cleveland city datum; 1.51 feet below the plane used for harbor improvements on Lake Erie; 13.72 feet above the upper miter sill of entrance lock of Welland Canal at Port Colborne, as given by Thomas Monro, engineer Soulanges Canal, and 10.39 feet above the upper miter sill of the guard lock of Erie Canal at Black Rock, as deduced from data by J. L. Little, division engineer, and George W. Rafter, special engineer, Erie Canal.

The mean surface of Lake Erie for the period of thirty-six years, from 1860 to 1895, is 2.32 feet below the plane of reference, or 572.88 feet above mean tide at New York City; for the period of twenty-five years, from 1871 to 1895, it is 2.41 feet below the plane of reference, or 572.79 feet. The mean surface as determined by the United States Lake Survey for the period of sixteen years, from 1860 to 1875, is 572.86 feet, and this is the generally accepted value.

As regards annual variation, the lake is generally highest in the month of June and lowest in the month of February.

An examination of the record for the period of thirty-six years, from 1860 to 1895, develops the following:

	Feet.
Range mean annual variation	1.22
Mean annual range	1.60
Greatest annual range (1892)	2.28
Least annual range (1895)	.87
Highest monthly mean water, June, 1876 (below plane of reference)	.59
Lowest monthly mean water, November, 1895 (below plane of reference)	4.41
Greatest range in monthly mean waters	3.82
Highest annual mean water, 1876 (below plane of reference)	1.41
Lowest annual mean water, 1895 (below plane of reference)	3.94
Greatest range in annual mean waters	2.53

The data for the table of monthly mean water levels for Lake Erie at Erie, Pa., were obtained from the same sources as those at Cleveland, Ohio, and the same has been checked with the original record by Mr. Blunt. Three errors in monthly means as printed in the annual reports have been corrected.

LAKE ONTARIO (TABLES NOS. 9 AND 10).

The data for the table of monthly means of water levels for Lake Ontario at Oswego, N. Y., were obtained as follows: From January, 1860, to December, 1890, from manuscript furnished by Maj. W. S. Stanton, Corps of Engineers, U. S. A., at Oswego, N. Y.; from January, 1891, to June, 1894, from the annual reports of the Chief of Engineers, U. S. A., 1892 to 1894; from July, 1894, to December, 1895, from manuscript furnished by Major Stanton. That portion compiled from the published reports has been checked with the original record in the office of Major Stanton by William Pierson Judson, United States assistant engineer.

The plane of reference for the water levels is that adopted by the United States engineer office at Oswego, and is the zero of the United States engineer gauge at Oswego. According to the United States Lake Survey,[1] the elevation of the zero of the gauge is 244.21 feet above mean tide at New York City.

The plane of standard high water for Lake Ontario has been taken as the monthly mean water of May, 1870, at Oswego, which is highest monthly mean water level during the period of thirty-six years 1860 to 1895. This monthly mean water is 4.83 feet above the zero of the gauge. The elevation of standard high water is therefore 244.21+4.83, or 249.04 feet above mean tide at New York City.

The plane of standard low water for Lake Ontario is equivalent to that for Lake Michigan, and is the plane at or below which monthly mean water has stood not more than an aggregate of ten months during the season of navigation out of the aggregate of nineteen lowest monthly mean waters occurring during the period of thirty-six years, 1860 to 1895. The following is the record:

Nineteen lowest monthly mean water levels above the zero of the Oswego gauge during the period 1860 to 1895.

Year.	Month.	Reading.	Year.	Month.	Reading.
		Feet.			*Feet.*
1872	February	0.39	1892	February	0.36
	March	.23	1895	January	.37
	December	.23		February	.31
1873	January	.19		March	.21
	February	.26		August	.22
	March	.38		September	—.12
1875	February	.26		October	—.46
1891	November	.32		November	—.71
	December	.29		December	—.68
1892	January	.39			

Properly the above table should contain only eighteen months in order to make it correspond with that of Lake Michigan, but inasmuch as the next reading to reject would be 0.39, and as there are two such readings, therefore it is immaterial whether eighteen or nineteen readings are used.

[1] See Final Report of United States Lake Survey, Professional Papers, Corps of Engineers, U. S. A., No. 24, page 609.

The following are the lowest monthly means during the season of navigation, which excludes the months of January, February, and March:

Year.	Month.	Reading.	Year.	Month.	Reading.
		Feet.			*Feet.*
1872	December	0.23	1895	September	—0.12
1891	November	.32		October	— .46
	December	.29		November	— .71
1895	August	+ .22		December	— .68

The reading + 0.32 of November, 1891, determines the plane of standard low water, and its elevation is 244.21 + 0.32, or 244.53 feet above mean tide at New York City. This plane is 0.32 foot above the zero of the United States engineer water gauge at Oswego, N. Y.; 14.33 feet above the lower miter sill of the entrance lock to the Welland Canal at Port Dalhousie, as given by Thomas Monro, engineer Soulanges Canal; 0.87 foot below the zero of the harbor commissioner's water gauge at Toronto, as deduced from data furnished by E. H. Keating, city engineer; 0.32 foot above the plane used for United States harbor improvements for Lake Ontario, and 7.46 feet above the lower miter sill of Lock 18, of the Erie Canal at Oswego, as determined by William Pierson Judson, C. E., for the Commission.

The mean surface of Lake Ontario for the period of thirty-six years from 1860 to 1895 is 2.27 feet above the zero of the Oswego gauge, or 246.48 feet above mean tide at New York City; for the period of twenty-five years from 1871 to 1895 it is 2.05 feet above the zero of the Oswego gauge, or 246.26 feet above mean tide at New York City. The mean surface as determined by the United States Lake Survey for the period of sixteen years from 1860 to 1875 is 246.61 feet, and this is the generally accepted value. The United States Lake Survey result was obtained from the Charlotte water level record.

As regards annual variation, the lake is generally highest in the month of June and lowest in the month of December.

An examination of the record for the period of thirty-six years from 1860 to 1895 develops the following:

	Feet.
Range in mean annual variation	1.45
Mean annual range	2.02
Greatest annual range (1867)	3.65
Least annual range (1872)	1
Highest monthly mean water (May, 1870 above zero of Oswego gauge)	4.83
Lowest monthly mean water (November, 1895 below zero of Oswego gauge)	.71
Greatest range in monthly mean waters	5.54
Highest annual mean water (1862)	3.51
Lowest annual mean water (1895)	.17
Greatest range in annual mean waters	3.34

The data for the table of monthly means of water levels for Lake Ontario at Charlotte, N. Y., were obtained as follows: From January, 1860, to June, 1894, from the annual reports of the Chief of Engineers, U. S. A., 1876 to 1894, inclusive; from July, 1894, to December, 1895, from manuscript furnished by Major Stanton. The monthly mean readings from June, 1883, to June, 1894, inclusive, are 0.15 foot less than those given in the above-mentioned reports of the Chief of Engineers.

This correction was made because previous to June, 1883, the United States Lake Survey plane of reference is 249.04 feet above mean tide at New York City, and after and including June, 1883, the United States engineer office at Oswego used a plane of reference which is 249.19 feet above mean tide at New York City. The difference in elevation of these two planes is 0.15 foot. It was thought best to refer all the Charlotte readings to the plane of reference adopted by the United States Lake Survey in 1876.[1] The monthly mean readings from July, 1894, to December, 1895, were reduced to the United States Lake Survey plane of reference, whose elevation is 249.04 feet.

The plane of reference for the water levels at Charlotte is that adopted by the United States Lake Survey in 1876, and is the plane of an assumed high water of 1838. According to the United States Lake Survey[2] this plane of reference is 34.19 feet below the upper side of the water table of the light-house, at the south-southeast angle, east of the south window at Charlotte. The elevation of this bench mark is 283.23 feet.[3] The elevation of the plane of reference is, therefore, 283.23 — 34.19, or 294.04 feet above mean tide at New York City. This happens to coincide with the elevation of the plane of standard high water of Lake Ontario.

The Oswego water gauge was established in 1838 by Mr. John W. Judson, C. E., United States agent in charge of Lake Ontario harbors. Its zero was set at the then extreme low water, supposed to be that of 1819.[4] The gauge "is cut into the vertical face of the cut-stone masonry forming the breakwater. This masonry was founded upon the ledge of rock forming the shore from which the breakwater starts and has thus been free from any possibility of settlement." The information in this paragraph has been furnished by Mr. William Pierson Judson, C. E., Oswego, N. Y.

In view of the fact that no question has ever been raised in regard to the stability of the Oswego gauge, while there has been in regard to the Charlotte gauge, all deductions for standard water levels have been derived from the Oswego gauge record.

ST. LAWRENCE RIVER AT VALLEYFIELD (TABLE NO. 11).

The data for the table of monthly mean water levels for the St. Lawrence River at Valleyfield, Province of Quebec, were furnished by Thomas Monro, engineer Soulanges Canal, at Coteau Landing, Province of Quebec. In the original record the readings are given in feet and inches, but in this table the monthly mean readings are given in feet and decimals of a foot. The monthly means were reduced from the daily readings and checked in the office of the Commission.

The plane of reference for the water levels is the upper miter sill of Lock No. 14 of the Beauharnois Canal. The elevation of this miter sill is 142.52 feet above mean tide at New York City, for which Thomas Monro, engineer of the Soulanges Canal, is the authority.

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[1] See Report Chief of Engineers, U. S. A., 1876, part 3, page 81, for plane of reference, and Final Report of United States Lake Survey, Professional Papers, Corps of Engineers, U. S. A., No. 24, page 614, for elevation of bench mark at Charlotte. Also see Report Chief of Engineers, U. S. A., 1887, part 3, page 2417, and Report Chief of Engineers, U. S. A., 1892, part 6, page 4382.

[2] See Report of the Chief of Engineers, U. S. A., 1876, part 3, page 81.

[3] See Professional Papers, Corps of Engineers, U. S. A., No. 24, page 614.

[4] Records since obtained indicate that this was probably the summer or autumn water, as the lowest water of 1819 appears to have been considerably lower (see Water Levels, etc., Prior to 1860)—L. E. C.

The plane of standard high water for the St. Lawrence River at Valleyfield has been taken as the monthly mean water of May, 1870, which is equivalent to that for Lake Ontario. The monthly mean water of May, 1870, reads 13.42 feet on the miter sill and the elevation of standard high water is, therefore, 142.52 + 13.42, or 155.94 feet above mean tide at New York City.

The plane of standard low water for the St. Lawrence River at Valleyfield is equivalent to that for Lake Michigan, and is the plane at or below which monthly mean water has stood not more than an aggregate of ten months during the season of navigation out of the aggregate of nineteen lowest monthly mean waters occurring during the period of thirty six years, 1860 to 1895. The following is the record:

Nineteen lowest monthly means of water levels above the upper miter sill of Lock No. 14 at Valleyfield during the period 1860 to 1895.

Year.	Month.	Reading.	Year.	Month.	Reading.
		Feet.			*Feet.*
1872	February	10.36	1893	February	10.53
	March	10.31	1895	February	10.57
1873	March	10.98		March	10.68
1875	February	10.52		July	10.96
1881	January	10.98		August	10.98
	February	10.73		September	10.54
1885	March	10.03		October	10.39
1888	February	10.59		November	10.17
1892	February	10.74		December	10.47
	March	10.83			

Properly the above table should contain only eighteen months in order to make it correspond with that of Lake Michigan, but inasmuch as the next reading to reject would be 10.98, and as there are two such readings, therefore, it is immaterial whether eighteen or nineteen readings are used.

The following are the lowest monthly means during the season of navigation, which excludes the months of January, February, and March:

Year.	Month.	Reading.	Year.	Month.	Reading.
		Feet.			*Feet.*
1895	July	10.96	1895	October	10.39
	August	10.98		November	10.17
	September	10.54		December	10.47

The reading + 10.98 feet of August, 1895, determines the plane of standard low water, and its elevation is 142.52 + 10.98, or 153.50 feet above mean tide at New York City. Extreme low water occurred on November 9, and 25, 1895, when the reading was 9.5 feet. This corresponds to an elevation of 152.02 feet above mean tide at New York City.

The mean surface of the St. Lawrence River at Valleyfield, for the period of thirty-six years from 1860 to 1895, is 12.14 feet above the upper miter sill of Lock No. 14, or 154.66 feet above mean tide at New York City. For the period of twenty-five years, from 1871 to 1895, it is 11.99 feet above the upper miter sill or 154.51 feet above mean tide at New York City.

As regards annual variation the St. Lawrence River at Valleyfield is generally highest in the month of May and lowest in the month of November.

An examination of the record for the period of thirty-six years, from 1860 to 1895, develops the following:

	Feet.
Range in mean annual variation	0.86
Mean annual range	1.50
Greatest annual range (1885)	2.85
Least annual range (1860)	.40
Highest monthly mean water (May, 1862, above upper miter sill of Lock 14)	13.76
Lowest monthly mean water (March, 1885, above upper miter sill of Lock 14)	10.03
Greatest range in monthly mean water	3.73
Highest annual mean water (1861)	13.07
Lowest annual mean water (1895)	10.91
Greatest range in annual mean water	2.16

ST. LAWRENCE RIVER AT MONTREAL (TABLE NO. 12).

The table of monthly means of water levels for the St. Lawrence River at Montreal, Province of Quebec, was compiled from a table furnished by John Kennedy, chief engineer harbor commissioners Montreal, and which is given in full as Table No. 14.

The plane of reference for the water levels is the lower miter sill of old lower lock of the Lachine Canal. The elevation of this miter sill is 7.10 feet above mean tide at New York City. This elevation is deduced from that given by R. Steckel, engineer in charge of Canadian geodetic leveling.[1] The Canadian geodetic levels are referred to an approximate mean tide of the Atlantic Ocean, which is 4.441 feet below the mean tide at New York City. This difference was found when the Canadian levels were connected with the United States Coast and Geodetic Survey levels at Rouses Point, New York.[1]

The plane of standard high water for the St. Lawrence River at Montreal is "the highest water possible during the season of navigation (at springs) with weather and atmospheric pressure in a normal condition." Its elevation is 35.78 feet above mean tide at New York City.[2]

The plane of standard low water for the St. Lawrence River at Montreal corresponds to a stage of 16 feet above the lower miter sill of old lock (No. 1) of the Lachine Canal, and is the same as that deduced by R. Steckel, engineer in charge of Canadian geodetic leveling.[3] The elevation of this plane is 7.10+16.00, or 23.10 feet above mean tide at New York City. This plane is 0.33 feet below the plane used in the Montreal harbor and ship channel improvements. The latter plane is 16 feet 4 inches, or 16.33 above the lower miter sill of old lower lock No. 1.[4] Extreme low water occurred in October, 1895, when the reading was 13 feet 2 inches, or 13.17 on the miter sill. This corresponds to an elevation of 20.27 feet above mean tide at New York City.

The plane of standard low water is also 0.08 feet below the equivalent plane of standard low water deduced in a similar manner as the plane of standard low water for the several Great Lakes and the St. Lawrence River at Valleyfield. The equivalent plane of standard low water would be the plane at or below which monthly mean water has stood not more than an aggregate of ten months during the season of

[1] See Annual Report Minister of Public Works, Canada, 1890-91, Part II, pages 109 and 8.
[2] Ibid., pages 8 and 117, and Plate XXIV.
[3] See Annual Report Minister of Public Works, Canada, 1890-1891, Part II, page 114.
[4] See Annual Report of the Harbor Commissioners of Montreal, 1895, page 86.

navigation out of the aggregate of eighteen lowest monthly mean waters occurring during the period of thirty-six years—1860 to 1895. The following is the record:

Eighteen lowest monthly means of water levels above the lower miter sill of old Lock No. 1, Lachine Canal, during the period 1860 to 1895.

Year.	Month.	Reading.	Year.	Month.	Reading.
		Feet.			*Feet.*
1868	October	16.42	1889	November	16.33
1871	November	16.42	1891	October	15.92
1874	November	16.42		November	15.67
1879	November	16.08	1894	September	16.17
1881	October	15.75	1895	July	15.83
	November	16.08		August	15.33
	December	16.25		September	14.50
1887	September	16.08		October	13.83
	November	16.17		November	13.83

The following are the ten lowest monthly means during the season of navigation, which excludes the months of January, February, and March:

Year.	Month.	Reading.	Year.	Month.	Reading.
		Feet.			*Feet.*
1881	October	15.75	1895	July	15.83
	November	16.08		August	15.33
1887	September	16.08		September	14.50
1891	October	15.92		October	13.83
	November	15.67		November	13.83

The reading 16.08 feet of November, 1881, and September, 1887 (also of November, 1879), would determine the equivalent plane of standard low water, and its elevation would be 7.10+16.08, or 23.18 feet above mean tide at New York City.

As regards annual variation, the St. Lawrence River at Montreal is generally highest in January and lowest in October.

LAKE CHAMPLAIN AND RIVER RICHELIEU (TABLES NOS. 13 AND 13a).

The data for the table of monthly means of water levels for Lake Champlain at Fort Montgomery, N. Y., were furnished by Capt. Smith S. Leach, Corps of Engineers, United States Army, at Burlington, Vt. The table, as compiled, has been compared with the original record in the office of Captain Leach by F. M. Barstow, United States assistant engineer.

The plane of reference for the water levels is the zero of the United States engineer gauge at Fort Montgomery, and its elevation is 94.53 feet[1] above mean tide at New York City.

The plane of standard high water for Lake Champlain has been taken as the high water of May 4, 1869, which is the highest on record. The elevation of the plane of standard high water is 103.78 feet above mean tide at New York City. This was obtained as follows: The records of the Central Vermont Railroad show that the high water of May 4, 1869, is 9.25 feet above the low water of October 16, 1880. The record furnished by Captain Leach shows that on October 16, 1880, the water

[1] See Appendix No. 7, Report of United States Coast and Geodetic Survey, 1887, page 172.

was at the zero of the United States engineer gauge at Fort Montgomery. The elevation of the high water is, therefore, 94.53+9.25, or 103.78 feet. As a check on this the records of the Champlain Transportation Company, kept at Shelburne Harbor, near Burlington, Vt., show that high water of May, 1869, is 9.17 feet above low water of October, 1880.[1]

The plane of standard low water for Lake Champlain is equivalent to that for Lake Michigan, and is the plane at or below which monthly mean water has stood not more than an aggregate of ten months during the season of navigation out of the aggregate of eighteen lowest monthly mean waters occurring during the period of twenty-five years, 1871 to 1895. The following is the record:

Eighteen lowest monthly means of water levels above the zero of the United States engineer gauge at Fort Montgomery during the period 1871 to 1895.

Year.	Month.	Reading.	Year.	Month.	Reading.
		Feet.			*Feet.*
1876	December	0.48	1883	November	0.40
1877	January	.46		December	.46
	February	.54	1884	January	.56
1880	September	.31		October	.48
	October	.15	1887	October	.58
1882	December	.30		November	.47
1883	January	.20	1891	November	.50
	February	.50	1894	September	.59
	October	.40		October	.56

The following are the ten lowest monthly means during the season of navigation, which excludes the months of January, February, and March:

Year.	Month.	Reading.	Year.	Month.	Reading.
		Feet.			*Feet.*
1876	December	0.48	1883	November	0.40
1880	September	.31		December	.46
	October	.15	1884	October	.48
1882	December	.30	1887	November	.47
1883	October	.40	1891	November	.50

The reading +0.50 of November, 1891, determines the plane of standard low water, and its elevation is 94.53+0.50, or 95.03 feet above mean tide at New York City. This plane is 9.11 feet above the lower miter sill of Lock No. 23 of the Champlain Canal at Whitehall, as determined for the Commission from a bench mark of the United States Coast and Geodetic Survey, by Albert J. Himes, resident engineer, Erie Canal.

Extreme low water of Lake Champlain is that observed on October 12, 1880, when the reading on the United States engineer gauge at Fort Montgomery was −0.14 feet.[2] The elevation of this extreme low water is 94.53−0.14, or 94.39 feet above mean tide at New York City.

The incomplete record at St. Johns (Table 13a), prior to 1871, indicates that the standard low-water plane would not be materially changed if deduced from a record for thirty-six years, 1860–1895.

[1] Information furnished by F. W. Baldwin, general superintendent Central Vermont Railroad, St. Albans, Vt.; G. F. Bixby, editor and proprietor of the Plattsburg Republican, Plattsburg, N. Y., and George Rushlow, general manager Champlain Transportation Company, Burlington, Vt.

[2] See Appendix No. 7, Report of United States Coast and Geodetic Survey, 1887.

The mean surface of Lake Champlain for the period of twenty-five years, from 1871 to 1895, is 2.67 feet above the zero of the Fort Montgomery gauge, or 97.20 feet above mean tide at New York City. The mean surface as determined by the United States Coast and Geodetic Survey[1] for the period of twelve years, from 1871 to 1882, is 97.17 feet above mean tide at New York City.

As regards annual variation, the lake is generally highest in the month of May and lowest in the month of October.

An examination of the record for the period of twenty-five years, from 1871 to 1895, develops the following:

	Feet.
Range in mean annual variation	3.59
Mean annual range	4.22
Greatest annual range (in 1876)	6.13
Least annual range (in 1872)	2.36
Highest monthly mean water (May, 1876)	6.61
Lowest monthly mean water (October, 1880)	0.15
Greatest range in monthly mean waters	6.46
Highest annual mean water (1890)	3.65
Lowest annual mean water (1883)	1.80
Greatest range in annual mean waters	1.85

The data for the table of highest and lowest depth of water on the upper miter sill of Lock No. 1 of the Chambly Canal, River Richelieu, at St. Johns, Province of Quebec, were obtained from the annual reports of the department of public works, Canada, 1867 to 1871, except for the "highest" in April, 1869, which was taken from the annual report for 1885, where it is given as 13.87 feet, by R. Steckel, engineer in charge of Canadian geodetic leveling, instead of 13 feet 10 inches, as given in the annual report for 1869.

This table (13a) is given as supplemental to that for Lake Champlain, there being no water-level record obtainable for Lake Champlain previous to 1871.

The slopes in the River Richelieu from Lake Champlain, at Fort Montgomery, to Lock No. 1 of the Chambly Canal, at St. Johns, are given by R. Steckel, engineer in charge of geodetic leveling,[2] as follows:

	Feet.
At extreme low water	0.38
At extreme high water, about	2.00

The corresponding elevation of Fort Montgomery would be as follows:

Above mean tide at New York City:	Feet.
At extreme low water	93.67
At extreme high water	103.28

The plane of standard high water for the River Richelieu at St. Johns has been taken as the high water of April, 1869, and its elevation is 101.28 feet above mean tide at New York City.

The plane of standard low water for the River Richelieu at St. Johns is equivalent to that for Lake Champlain and it is derived by subtracting the low-water slope of 0.38 foot from the standard low water for Lake Champlain. The elevation of the plane of standard low water is therefore 95.03—0.38, or 94.65 feet above mean tide at New York City.

The elevation of the upper miter sill of Lock No. 1 of the Chambly Canal is 87.41 feet above mean tide at New York City. This elevation is derived from the Canadian geodetic levels, which give the eleva-

[1] See Appendix No. 7, Report of United States Coast and Geodetic Survey, 1887.
[2] See Annual Report Minister of Public Works, Canada, 1884–85, Appendix No. 7.

tion as 91.85 feet above an approximate mean tide of the Atlantic Ocean. The connection between the Canadian and United States levels at Rouse Point, near Fort Montgomery, shows that the Canadian datum is 4.441 feet below the United States datum, which is mean tide at New York City.

The Canadian levels are, therefore, corrected by subtracting 4.441 feet.[1] In the annual report of the minister of public works, Canada, the Canadian levels are referred to another datum 100 feet below, which corresponds to 94.63 feet above mean tide at New York City, or, in other words, the elevation of mean tide at New York City is 194.63 feet below the Canadian datum used in annual report of 1884–85.

ST. LAWRENCE RIVER AT MONTREAL (TABLE NO. 14)

Table No. 14 is a copy of the record furnished by John Kennedy, chief engineer, harbor commissioners, Montreal. The table gives depth of high, low, and mean water level for each month on the miter sill of Lock No. 1, Lachine Canal, for the forty-six years from 1850 to 1895, inclusive.

In the original record the readings are given in feet and inches, but in this table the readings are given in feet and decimals of a foot.

This table has been checked with the original record in the office of the harbor commissioners by the chief engineer, Mr. John Kennedy.

ST. LAWRENCE RIVER FROM PRESCOTT TO MONTREAL (TABLE NO. 15).

This table has been compiled for 1870, a characteristic high-water year, and for 1895, a characteristic low-water year, in order to determine standard high water and standard low water at ruling points of the St. Lawrence River between Lake Ontario and Montreal. The complete record for Lake Ontario and for the St. Lawrence at Valleyfield and at Montreal has been presented in Tables No. 9, 10, 11, 12, and 14, and has been discussed for each point under its proper head, and it remains to deduce the equivalent results for the intermediate points.

The record of Ogdensburg, N. Y., opposite Prescott, for 1870, is compiled from the Report of the Chief of Engineers, United States Army, for 1893, Part VI, page 4385; for 1895, from manuscript furnished by John C. Churchill, jr., C. E., of Ogdensburg. The record at the terminal locks at the several canals, except at Valleyfield and Montreal, is furnished by the department of railways and canals of Canada.

The approximate determination of the zero of the Ogdensburg gauge is as follows: The mean reading of the Oswego gauge for a period of six months, May to October, 1895, is + 0.29 foot, and for the same period at Ogdensburg, —1.08 feet. The slope of the river from Kingston to Prescott, as given on profile compiled by Thomas Monro for the Deep Waterways Commission of Canada, is 0.25 foot, and the elevation of the zero of the Oswego gauge is 244.21 feet above mean tide at New York City. The zero of gauge at Ogdensburg is therefore $244.21 + 0.29 - 0.25 + 1.08 = 245.33$ feet above mean tide at New York City. The elevation of bench mark on doorsill of light-house reads 6.75 feet on gauge, and its elevation is therefore $245.33 + 6.75 = 252.08$ feet.

The records given for the other points of the tables are the depths on the miter sills of the several locks, which are all referred to mean tide at New York. The elevation of the miter sill of old Lock 5 at Lachine is deduced from the line of precise levels from the international

[1] See Annual Report Minister of Public Works, Canada, 1890–91, Part II.

bench mark at Rouse Point, N. Y., as run by R. Steckel, engineer in charge of Canadian geodetic leveling. The elevation of the miter sill of old Lock 1, at Montreal, is as given by the same authority.

The elevations of the reference miter sills at the several other points are as given by Thomas Monro on the profile heretofore mentioned.

In deducing results it will be convenient to consider the St. Lawrence River in two divisions: First, between Lake Ontario and Valleyfield; second, between Valleyfield and Montreal.

Standard elevations have already been independently determined for Lake Ontario and for Lake St. Francis at Valleyfield. It remains, therefore, to determine the equivalent stages at Ogdensburg and at the terminal locks of the Williamsburg and Cornwall canals.

Standard high water is the monthly average for May, 1870. For Lake Ontario it is the highest water of record at Oswego. For the St. Lawrence River at Valleyfield, it is 0.05 foot lower than the monthly average for May, 1876, although the general average for the year 1870 ruled higher. The following table gives the results:

Locality.	Reading May, 1870.	Plane of reference.	Elevation standard high water.
	Feet.	*Feet.*	*Feet.*
Lake Ontario, Oswego, N. Y	4.83	244.21	249.04
Ogdensburg, N. Y	3.24	245.33	248.57
Galops Canal, Old Lock 27	12.67	235.15	247.82
Galops Canal, Old Lock 25	15.67	218.52	234.19
Rapide Plat Canal, Old Lock 23	12.58	205.82	218.40
Farrans Point Canal, Old Lock 22	10.83	193.77	204.60
Cornwall Canal, Old Lock 15	12.42	144.86	157.28
Valleyfield, Province of Quebec, Lock 14	13.42	142.52	155.94

The average reading for six months at Oswego, from May to October, 1895, is 0.29 foot, which is 0.03 foot below standard low water as determined for Lake Ontario. The average reading for the same period at Valleyfield, is 10.93 feet, which is 0.05 foot below standard low water as determined for Lake St. Francis at Valleyfield. This is a practical agreement, and an arbitrary of 0.03 foot is therefore added to the averages for the same period at intermediate points in determining standard low water. The following table gives the results:

Locality.	Average reading.	Reading standard low water.	Elevation.	
			Plane of reference.	Standard low water.
	Feet.	*Feet.*	*Feet.*	*Feet.*
Lake Ontario, Oswego, N. Y	0.29	0.32	244.21	244.53
Ogdensburg, N. Y	—1.08	—1.05	245.33	244.28
Galops Canal, Old Lock 27	8.28	8.31	235.15	243.46
Galops Canal, Old Lock 25	9.46	9.49	218.52	228.01
Rapide Plat Canal, Old Lock 24	.....	(7.18)	217.33	(224.51)
Rapide Plat Canal, Old Lock 23	6.96	6.99	205.82	212.81
Farrans Point Canal, Old Lock 22	7.92	7.95	193.77	201.72
Cornwall Canal, Old Lock 21	.....	(8.60)	192.53	(201.13)
Cornwall Canal, New Lock 15	14.68	14.71	139.28	153.99
Valleyfield, Province of Quebec, Lock 14	10.93	10.98	142.52	153.50

The interpolated quantities are approximated from the extreme readings in the report of the minister of railways and canals.

Extreme low water, as given by Thomas Monro on profile before mentioned, in comparison with standard low water and lowest monthly readings, is as follows:

Locality.	Standard low water.	Lowest month, November, 1895.	Extreme low water.	Time of extreme low water, 1895.
	Feet.	*Feet.*	*Feet.*	
Lake Ontario, Oswego, N. Y.	+0.32	—0.71	a —0.96	November.
Ogdensburg, N. Y.	—1.05	(—2.08)	b —2.33	Do.
Galops Canal, old Lock 27	8.31	7.42	6.74	November 9.
Galops Canal, old Lock 25	9.49	7.83	6.67	Do.
Rapide Plat Canal, old Lock 24	(7.18)	(5.58)	4.50	Do.
Rapide Plat Canal, old Lock 23	6.99	5.50	4.56	November 23.
Farran's Point Canal, old Lock 22	7.95	6.67	5.83	November 9.
Cornwall Canal, old Lock 21	(8.60)	(7.54)	7.00	Do.
Cornwall Canal, new Lock 15	14.71	13.92	13.50	November 21.
Valleyfield, Lock 14	10.98	10.17	c 9.36	November 9.

a As determined at Kingston graving dock.
b Given for Prescott.
c The lowest reading in the record is 9.50 feet on November 9 and November 25, as given in the discussion, St. Lawrence at Valleyfield (Table No. 11).

The interpolated quantities are approximated from the extreme readings given in report of minister of railways and canals.

The usual period of highest water between Lake Ontario and Valleyfield occurs in May or June; and of lowest water, in November or December.

Between Valleyfield and Montreal, a determination is required at two points: Lock No. 6 of the Beauharnois Canal at Melocheville, the head of Lake St. Louis; and at Lock No. 5 of the Lachine Canal at Lachine, the foot of the lake.

The high water of May, 1876, is the highest water of record below the junction of the Ottawa River and is some 2 feet higher than the high water of May, 1870, on Lake St. Louis, and has been adopted as standard high water. The extreme normal reading on the miter sill of old Lock No. 5, at Lachine, as given by Mr. Steckel,[1] is 17.13 feet, or elevation 75.52 feet above mean tide at New York City. The extreme reading on the miter sill of Lock No. 6, at Melocheville, is 16.67[2] feet, or 77.50 feet above mean tide at New York City.

The extreme normal reading on the miter sill of old Lock No. 1, at Montreal, as given by Mr. Steckel in the report above referred to, is 28.68 feet, or 35.78 feet above mean tide at New York City.

In determining standard low water, the months of August, September, October, and November are used. The earlier months give anomalous results owing to lack of coincidence in the stages of the Ottawa River and the St. Lawrence above the junction, during the high-water season. During the low-water months, the variations from this cause are less apparent.

The reading for August, 1895, at Valleyfield, is at standard low water. The equivalent readings at Melocheville, Lachine, and Montreal are given in the first column of the following table. The average reading for four months, August, September, October, and November for the years 1895, 1879, 1868, and 1865, are also entered for each of the four points. The record from which the readings for 1879, 1868, and 1865

[1] Report, 1890–91, Minister of Public Works, Canada.
[2] Report, 1876, Minister of Public Works, Canada.

are compiled was furnished by John Kennedy, chief engineer, harbor commissioners, Montreal.[1]

The arbitrary for each of the readings at Valleyfield is obtained by taking therefrom the reading of standard low water, and this is applied in computing the equivalent standard low water at Melocheville and Lachine.

The arbitrary is multiplied by 1.60 in computing the equivalent standard low water at Montreal, as this is about the ratio of the amplitude of the fluctuations in stage at low water between Montreal and points above.

Designation.	1895, August. Standard low water.	1895, four months.	1879, four months.	1868, four months.	1865, four months.
	Feet.	*Feet.*	*Feet.*	*Feet.*	*Feet.*
Valleyfield:					
Average reading	10.98	10.52	11.50	11.55	11.91
+Arbitrary	0.00	+0.46	—0.52	—0.57	—0.93
Melocheville:					
Average reading	9.17	8.69			
Computed standard low water	9.17	9.15			
Lachine:					
Average reading	9.50	8.90	10.28	9.94	10.39
Computed standard low water	9.50	9.36	9.76	9.37	9.46
Montreal:					
Average reading	15.33	14.37	16.81	16.90	17.67
(+Arbitrary × 1.6=equivalent.) Equivalent arbitrary	0.00	+0.74	—0.83	—0.91	—1.49
Computed standard low water	15.33	15.11	15.98	15.99	16.18

The table gives the readings, the arbitraries, and the computed equivalent standard low water for Melocheville, Lachine, and Montreal, as deduced from Valleyfield.

An inspection of the table shows that the result for 1879, at Lachine, is anomalous. Mr. Steckel,[2] in the report before referred to, determined by a simultaneous reading in November, 1879, the reading at Lachine equivalent to 16 feet at Montreal. This was 9.21 feet, or 0.55 foot less than that deduced in the table. The determination between Valleyfield and Montreal is also consistent. The record for 1879, at Lachine, is anomalous and is omitted in the further consideration.

The reading of August, 1895, is adopted at Melocheville, or 9.17 feet on miter sill of Lock No. 6. The elevation of the miter sill is 60.83 feet. Standard low water at Melocheville is, therefore, 9.17+60.83=70 feet above mean tide at New York City.

The reading for standard low water at Lachine may be taken at 9.41 feet on the miter sill of old Lock 5. The elevation of the miter sill is 58.39 feet. Standard low water at Lachine is, therefore, 9.41+58.39=67.80 feet above mean tide at New York City.

The table gives the equivalent at Montreal of standard low water at Valleyfield. In the same manner, the equivalent at Montreal of standard low water at Lachine is determined. The reading at Lachine is

[1] *Lachine depths on miter sill of old Lock No. 5.*

Month.	1865.	1868.	1879.	Month.	1865.	1868.	1879.
August	11.36	10.15	10.80	October	9.92	9.73	10.08
September	10.45	10	10.44	November	9.84	9.87	9.79

[2] Report, 1890–91, Minister Public Works, Canada.

9.41 feet on miter sill of old Lock No. 5, and the equivalents on the miter sill of old Lock No. 1 at Montreal are as follows:

	Feet.
August, 1895	15.19
August, September, October, and November, 1895	15.18
Same, four months of 1868	16.05
Same, four months of 1865	16.10

The mean of the determinations for 1868 and 1865 is 16.08 feet, which is the same as standard low water at Montreal as heretofore determined from the record of thirty-six years in the same manner as for the several lakes. The determination for 1895 is less by 0.90 foot.

Extreme low water, as given by Thomas Monro on profile before mentioned in comparison with standard low water and lowest monthly reading, is as follows:

Locality.	Standard low water.	Lowest month, November, 1895.	Extreme low water.	Time of extreme low water, 1895.
	Feet.	*Feet.*	*Feet.*	
Melocheville, Lock 6	9.17	8.33	7.82	November 5.
Lachine, old lock 5	9.41	8.50	8.03	November 9.
Montreal, old lock 1	a 15.18	13.83	b 13.25	November 5.

a Standard adopted, 16 feet.
b Extreme low water of October, 13.17 feet, as given in Table No. 14.

In the "Annual reports of the harbor commissioners of Montreal," for 1895, page 85 et seq., Mr. John Kennedy, chief engineer, presents and discusses data in regard to the low-water condition. The following table gives the absolute fall from canal entrance to Maisonneuve about 18,400 feet, and between Maisonneuve and Longue Point about 15,600 feet:

Date.	Canal entrance to Maisonneuve.	Maisonneuve to Longue Point.	Canal entrance to Longue Point.
	Feet.	*Feet.*	*Feet.*
December 3, 1888	2.80	.....	.....
November 8, 1889	2.53	0.40	2.93
September 18, 1895	1.80	.....	.....
November 8, 1895	1.71	0.21	1.92

This table confirms the deduction previously made, and would seem to show a change of about 1 foot within 6½ miles of canal entrance and mostly within 3½ miles. In this vicinity there is naturally a local concentration of slope, which the harbor works seem to have greatly reduced.

The standard low-water plane at Montreal, as heretofore determined, covers the ten lowest months of the season of navigation, out of the aggregate of eighteen lowest months occurring in thirty six years, and corresponds to the planes determined for the several lakes. In reality it is the plane of the highest of the ten months.

If the actual plane had not changed, several of the low-water readings would have been higher. An inspection of the record, however, shows several additional months within two or three tenths of the adopted plane, so that the change would not have been great. On the other hand, had the conditions now obtaining existed throughout the thirty-six years (1860–1895) the plane deduced would have been lower by about 1 foot.

It would seem, therefore, that while the standard low water adopted

is an approximate equivalent of past conditions, it is not applicable to the future when material changes in channels of discharge are taking place.

The following table gives standard low water as referred to other points not mentioned in the foregoing discussion:

Locality.	Reading standard low water.	Elevation plane of reference.
Kingston, sill of Graving dock	15.33	229.20
Galops Canal, upper entrance, new sill	14.75	228.71
Rapide Plat Canal, upper entrance, new sill	(15.18)	209.33
Rapide Plat Canal, lower entrance, new sill	15.93	196.88
Cornwall Canal, upper entrance, new sill	(15.02)	186.11
Soulanges Canal, upper entrance, sill	16.18	137.32
Soulanges Canal, lower entrance, sill	16.18	53.82
Lachine Canal, upper entrance, new sill	14.46	53.34

DIAGRAMS.

WATER LEVELS FOR THE GREAT LAKES AND ST. LAWRENCE RIVER.

(Diagrams No. 1 and No. 1a.)

A series of diagrams has been prepared showing the annual water-level curves for Lakes Superior, Michigan, Huron, Erie, and Ontario, St. Lawrence River at Valleyfield and at Montreal, and Lake Champlain. Each of the curves covers a period of thirty-six years, from 1860 to 1895, except that for Lake Champlain, which covers the period of twenty-five years, from 1871 to 1895. The data for the curves are given in the tables of water levels and each curve is referred to the plane of reference noted in its table.[1]

SLOPES IN THE RIVERS CONNECTING THE LAKES.

(Diagram No. 2.)

A series of diagrams has been prepared showing the monthly mean slopes or falls and the variation in the same in the St. Mary's River between Lake Superior and Sault Ste. Marie above the locks, between above the locks and below the locks, and between below the locks and Lake Huron; in the St. Clair and Detroit rivers between Lake Huron and Lake Erie, and in the Detroit River between the light-house depot at the foot of Mount Elliott avenue, Detroit, and Lake Erie. The period covered is for twenty-five years, from 1871 to 1895, except for Detroit River at light-house depot, where the period is eleven years, from 1871 to 1881.

The curves are shown in two series; in one, the absolute heights of the monthly mean water level above mean tide at New York are platted, and this shows the variation in the height of water surface and the slopes in the several rivers; in the other series, the upper lake or body of water is assumed to be level, and the ordinates of the curves represent the slope or fall to the lower lake or body of water.

The slope diagrams in the St. Marys River and in the Detroit River between Detroit and Lake Erie show the effect of ice in the winter months. This influence is not apparent in the total fall between Lake Superior and Lake Huron and between Lake Huron and Lake Erie.

[1] The record for the ten months ending with October, 1896, has been added to the diagrams.—L. E. C.

MEAN ANNUAL VARIATION.

(Diagram No. 3.)

A series of diagrams has been prepared showing the mean level by months. The complete curves show the mean variation or average change throughout the year.

In the curve for Lake Huron the twenty-five-year means are used, and the curve for Lake Michigan for the same period is outlined thereon, in order to show the relative variation in monthly means for the two lakes.

In the curve for the St. Lawrence River at Montreal a hypothetical curve for the winter months, and in the absence of ice, is shown by a dotted line. For December and April the readings are deduced by comparing the mean curve with the annual curves for years of no ice in these months. For January, February, and March the readings are approximated by comparison with the mean curves for Lake Champlain, the St. Lawrence River at Valleyfield, and the Ottawa River at Ottawa.

For purposes of comparison the mean curve for the Ottawa River at Ottawa has been outlined on the Montreal curve. This is deduced from the record of the depth on the lower miter sill of the entrance lock of the Rideau Canal at Ottawa, for the periods from 1850 to July, 1867, and from July, 1892, to June, 1895, as printed in the reports of the minister of public works and of the department of railways and canals.

VARIATION OF ANNUAL MEANS.

(Diagram No. 4.)

A series of diagrams has been prepared showing the variation in the annual means for the several lakes and the St. Lawrence River.

I have been assisted in compiling these notes by Mr. J. E. Maloney, who has completed the same since I left the service. I have, however, carefully gone over Mr. Maloney's work.

Very respectfully submitted.

ALEX. E. KASTL.

NOTE.—Mr. Maloney has supervised the preparation of the diagrams and worked up the memoranda which are appended.—L. E. C.

MEMORANDA.

LAKE CHAMPLAIN.

Special efforts have been made to secure data for Lake Champlain, in addition to the record at Fort Montgomery furnished by the United States engineer office at Burlington, Vt. The Coast and Geodetic Survey, in Appendix No. 7, Annual Report for 1887, published a table and discussion covering a period of twelve years, from 1871 to 1882, inclusive, which is based on the record at Fort Montgomery. This table contains minor variations from the record as furnished by the United States engineers, which may be due to difference in reduction and interpretation of the daily readings.

An inquiry was sent to the State engineer and surveyor of New York, Hon. Campbell W. Adams, Albany, N. Y., and a reply received through

Albert J. Himes, resident engineer, eastern division of the Erie Canal, under date of March 2, 1896. Mr. Himes says:

I can find no evidence in the reports that any interest has ever been taken in a record of the stage of water on Lake Champlain.

A similar inquiry was sent to the superintendent of the State land survey, Hon. Verplanck Colvin, Albany, N. Y. He replied on March 14, 1896, in part as follows:

On examination, however, I do not find any records earlier than the fragmentary data of 1871, which from your letter I understand you already have.

Meantime, a letter had been addressed to G. F. Bixby, editor and proprietor of the Plattsburg Republican, Plattsburg, N. Y., who, it was learned, had given special attention to the subject of fluctuations. Mr. Bixby replied under date of February 24, 1896, in part as follows:

Since October, 1886, I have published at or near the first of every month a record of fluctuations of the water level of Lake Champlain at the center of the drawbridge of the Central Vermont Railroad Company, at Rouse Point, as kept by Mr. E. H. Starks, the bridge tender there. At that time I also gathered data from various sources, from old inhabitants, dock keepers, etc., from which was determined with approximate accuracy the extreme of fluctuations as far back as any records are available. From these data, on which the local authorities hereabout substantially agreed, it is found that the highest water ever known in Lake Champlain was May 4, 1869, when it was within 4 feet 5½ inches of the railroad track bench mark at Rouse Point, and that the lowest ever known was October 16, 1880, when it was 13 feet 8½ inches below the same bench mark, making the extreme fluctuation 9 feet 3 inches.

Mr. Bixby adds that no record was ever kept at the military post at Plattsburg, and he referred the inquiry to Capt. George Rushlow, general manager of the Champlain Transportation Company, Burlington, Vt., for further information.

Captain Rushlow replies under date of February 27, 1896, in part as follows:

Since the establishment of our shipbuilding plant at Shelburne Harbor in 1827, a record has always been kept. As you are doubtless aware, the extreme high water was in May, 1869, the extreme low water in October, 1880. The fluctuation between the two is 9 feet 2 inches.

In response to further inquiry, Captain Rushlow replies, under date of March 7, 1896:

I beg to say that the record mentioned in my letter of February 27 to Dr. Bixby, of Plattsburg, is not a monthly record, but since 1827, the establishing of our plant at Shelburne Harbor, a record has been kept of the extreme high and low water by marks on our wharf and buildings, and the record given by Dr. Bixby was the extreme high and low water since 1827.

An inquiry was also addressed to Prof. D. E. Goodrich, University of Vermont, Burlington, Vt., and answered under date of March 4, 1896. Professor Goodrich says:

After inquiries and some correspondence, I consider that you have already been furnished with all the information to be had, unless possibly something is to be added from the work of the Coast Survey on Lake Champlain.

Professor Goodrich inclosed a note from Captain Rushlow, and also a note from Prof. V. G. Barbour, dean of the engineering department, and at one time connected with the Coast Survey. Professor Barbour writes:

I know of no data concerning the level of the Lake Champlain other than that mentioned.

In reply to inquiries addressed to the Central Vermont Railroad, St. Albans, Vt., respecting records at the Rouse Point and Ticonderoga crossings, Mr. F. W. Baldwin, general superintendent, under date of April 27, 1896, furnishes their record "at Rouse Point from May 24,

1874, to April 18, 1896, inclusive." This record gives no additional information, and is chiefly valuable as a check on the one at Fort Montgomery.

In order to furnish some criterion of the fluctuations for the period from 1860 to 1870, inclusive, the record for the Richelieu River at St. Johns has been compiled from the reports of the minister of public works of Canada. This enables a judgment to be formed for the entire period of thirty-six years in comparison with the other lakes. It does not appear that a complete record for thirty-six years would materially change the results as indicated by the record of twenty-five years.

It is possible that the leveling up of the marks at the shipyard of the Champlain Transportation Company at Shelburne Harbor and the detailed record for the Richelieu River at St. Johns made prior to 1871 may furnish additional information of value; but otherwise the sources of information regarding the early fluctuations of Lake Champlain appear to be exhausted. The extreme fluctuations since 1826, a period of seventy years, and the detailed fluctuations since 1870, a period of twenty-five years, are well determined, and the general fluctuations for eight years previous to 1871 may be closely inferred.

ST. LAWRENCE RIVER.

The record of monthly means for the year 1895 at Cornwall and at Lachine, as finally tabulated, requires notice.

The readings for April, May, June, and July, as furnished for Cornwall, are given in the first column and those adopted in the second.

Month.	Original record.	Adopted record.
	Feet.	*Feet.*
April	10.92	(15.69)
May	9.67	15.25
June	9.50	15.08
July	12.75	(14.70)

The readings for May and June were assumed to have been taken on sill of old lock, and the difference in the elevation of the sills of the old and new locks, which is 5.58 feet, was added to these two readings.

The readings for April and July were assumed to be in error (probably a combination of readings on the two sills), and were replaced by values interpolated as noted at the foot of Table No. 15.

At Lachine a record was furnished for the miter sills of both the old and new locks. The following table contains the original record and a column giving the difference in readings:

Lachine, 1895.

Month.	Original record.		Difference.
	Old lock.	New lock.	
	Feet.	*Feet.*	*Feet.*
January	10.75	14.92	4.17
February	9.08	13.25	4.17
March	8.58	12.75	4.17
April	11.75	15.92	4.17
May	12.33	16.50	4.17
June	11.33	15.50	4.17
July	9.83	14	4.17
August	9.50	13.67	4.17
September	8.92	13.17	4.25
October	8.67	13.67	5
November	8.50	13.50	5
December	9.67	14.58	4.91

As the sills of the two locks differ in elevation 5.04 feet, it is evident that one of the records is in error some 10 inches from January to September. The record at the old lock is consistent with that for 1870 and for other years, and also with the record on Lock No. 6 at Melocheville, and is adopted as correct. The record at the new lock appears to be made up by adding an arbitrary to the record at the old lock, and this arbitrary appears to have been in error, except for the last three months.

LAKE ONTARIO.

The high water of 1838, at Charlotte, as established by Prof. C. Dewey, is 34.48 feet below bench mark on water table of light-house, or at elevation 283.23—34.48=248.75 feet above mean tide at New York. (See Report of Chief of Engineers, U. S. A., 1872, p. 1069; and Professional Papers, Corps of Engineers, U. S. A., No. 24, p. 614.) The high water of 1838, at Oswego, is given by Charles Whittlesey (see Smithsonian Contributions to Knowledge, vol. 12, 1860) as 3.04 feet below a certain zero or plane of reference, which Mr. William Pierson Judson, United States assistant engineer, at Oswego, states is the same as bench mark A, Oswego. The elevation of this bench mark is 251.96 feet, and the high water of 1838, at Oswego, is therefore 251.96 − 3.04=248.92 feet above mean tide at New York City.

The plane of reference for Lake Ontario, as used by the United States Lake Survey, is 34.19 feet below the bench mark on the light-house, or 249.04 feet above mean tide at New York City. This is not, therefore, the high water of 1838, but an arbitrary plane that was intended to be the equivalent of the high water of 1838 on Lake Erie, as determined by comparing the mean of the gauge readings for June, July, and August, 1874, and taking a plane for Lake Ontario as much above the mean as the actual high water of 1838 on Lake Erie was above the mean for the same period. It now appears that the plane for Lake Erie is 1.68 feet above the mean for Cleveland, while that for Lake Ontario is 1.80 feet above the mean for Oswego, and that the two planes do not correspond as intended. The plane does, however, correspond to the mean reading for May, 1870, at Oswego, or the highest water of record for Lake Ontario.

Some uncertainty attaches to the record at Charlotte, and certain reductions are made as explained in the foregoing text. Much consideration has been given this record, and for this purpose the information bearing thereon has been put at the disposal of the Commission by Maj. W. S. Stanton, the officer in charge. The zero of the Charlotte gauge was changed in 1883 to coincide with the zero of the Oswego gauge according to the determination made by the United States Lake Survey. A comparison of the direct readings for the three years, 1893 to 1895, gives a mean 0.07 foot greater at Oswego. A comparison for the months of June, July, and August, for the same years, gives a mean 0.08 foot greater at Oswego. Assuming the lake to be level, the zero of the Charlotte gauge is, therefore, actually higher than the zero of the Oswego gauge.

Since the above was written, a letter from William Pierson Judson, assistant engineer, by direction of Maj. W. S. Stanton, has been received under date of August 8, 1896, in part as follows:

The following copy of a communication just received from Mr. G. K. Gilbert, of the United States Geological Survey, may be of interest to you. He is studying lake levels and has recently visited Oswego and Charlotte. He says under date of August 1: At Charlotte I leveled from the zero of gauge to the bench mark on the

water table of the old light-house tower. This line was run twice, but with unequal conditions, and I gave the second determination greater weight in computing a result for adoption.

Zero at Charlotte below bench:	
First determination	38.937
Second determination	38.955
Adopted value	38.950

The elevation of the bench mark on the water table of the light-house as heretofore used is 283.23 feet above mean tide at New York City. The elevation of the zero of the Charlotte gauge is, therefore, 283.23 — 38.95 = 244.28 feet. This is 0.07 feet above the zero of the Oswego gauge and is the same as heretofore deduced by comparison of water levels.

These two determinations confirm the original determination of the light-house bench mark as made in 1875 by comparison of gauge readings at Oswego and Charlotte. It is apparent that the readings as given in the table (No. 10) from June, 1883, to December, 1895, inclusive, should be further reduced by 0.07 feet. This, however, does not satisfy all the anomalies of the Charlotte record.

The elevation of the zero of the gauge at Toronto is determined from the following record for 1895, furnished by the city engineer, E. H. Keating, in comparison with Oswego.

Monthly mean of the water as per gauge at the Queen's Wharf for the year 1895, in inches below the zero.

[Toronto harbor commissioners' gauge.]

	Inches.		Inches.
January	10	July	8½
February	13	August	11⅞
March	12½	September	14⅛
April	6⅛	October	20
May	3¼	November	22⅜
June	4.60	December	21

Annual mean, 12.3 inches = 1.02 feet below the zero.

The annual mean at Oswego for 1895 is 0.17 foot. The zero at Toronto is, therefore, 1.02 + 0.17 = 1.19 feet above the zero of the Oswego gauge, or 244.21 + 1.19 = 245.40[1] feet above mean tide at New York City.

The elevation of the lower miter sill of the entrance lock of the Rideau Canal at Kingston Mills is approximately determined by comparing the mean of the extreme monthly readings as given in the annual reports of the department of railways and canals, Dominion of Canada, for the period July, 1893, to June, 1895, inclusive, with the mean at Oswego for the same period.

The mean of all the readings at Kingston Mills is 7.85 feet. The mean for the same months at Oswego is 1.45 feet; the miter sill is, therefore, below zero of Oswego gauge 6.40 feet; the elevation of the miter sill is 244.21 — 6.40 = 237.81 feet above mean tide at New York City.

[1] Mr. Thos. Monro, from a comparison of the records for sixteen years—1860–1875—obtains an elevation of 245.36. (See "Elevations of Great Lakes," etc.)—L. E. C.

TABLES OF WATER LEVELS FOR THE GREAT LAKES AND ST. LAWRENCE RIVER.[1]

Table No. 1.—Lake Michigan at Milwaukee, Wis., 1860–1895.
Table No. 2.—Lake Huron at Point Aux Barques, Port Austin, and Sand Beach, Mich., 1860–1895.
Table No. 3.—Lake Superior at Superior, Wis., and Marquette, Mich., 1860–1895.
Table No. 4.—St. Marys River at Sault Ste. Marie, Mich., above the locks, 1871–1895.
Table No. 5.—St. Marys River at Sault Ste. Marie, Mich., below the locks, 1871–1895.
Table No. 6.—Detroit River at Light-House Depot, Detroit, Mich., 1867–1881.
Table No. 7.—Lake Erie at Cleveland, Ohio, 1860–1895.
Table No. 8.—Lake Erie at Erie, Pa., 1860–1895.
Table No. 9.—Lake Ontario at Oswego, N. Y., 1860–1895.
Table No. 10.—Lake Ontario at Charlotte, N. Y., 1860–1895.
Table No. 11.—St. Lawrence River at Valleyfield, Province of Quebec, 1860–1895.
Table No. 12.—St. Lawrence River at Montreal, Province of Quebec, 1860–1895.
Table No. 13.—Lake Champlain at Fort Montgomery, N. Y., 1871–1895.
Table No. 13a.—River Richelieu at St. Johns, Province of Quebec, 1863–1870.
Table No. 14.—St. Lawrence River at Montreal, Province of Quebec, 1850–1895.
Table No. 15.—St. Lawrence River from Prescott to Montreal, Provinces of Ontario and Quebec, for the years 1870 and 1895.
Supplemental table.—Water Records for 1896.

TABLE No. 1.—*Lake Michigan, at Milwaukee, Wis.*

[Monthly mean of water levels below the plane of reference of United States Lake Survey (high water of 1838). Elevation of the plane of reference above mean tide at New York City is 584.34 feet.]

Year.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Mean.
	Feet.	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*
1860	2.18	2.00	1.97	1.84	1.72	1.60	1.56	1.75	1.95	2.26	2.59	2.75	2.01
1861	2.86	2.77	2.38	2.28	1.86	1.70	1.57	1.83	1.64	1.76	1.99	2.16	2.03
1862	2.36	2.51	2.21	2.05	1.80	1.67	1.77	1.78	1.85	1.96	2.35	2.49	2.07
1863	2.56	2.51	2.52	2.52	2.31	2.22	2.27	2.40	2.58	2.67	3.11	2.77	2.54
1864	3.00	3.14	2.89	3.18	2.67	2.68	2.78	2.96	3.23	3.62	3.79	3.92	3.16
1865	4.13	4.04	3.87	3.38	3.22	3.18	2.75	2.73	2.85	3.00	3.65	3.96	3.40
1866	4.22	4.46	4.41	3.96	3.78	3.49	3.23	3.17	3.32	3.43	3.52	3.78	3.73
1867	3.80	3.75	3.57	3.28	3.06	2.75	2.60	2.67	2.94	3.27	3.73	4.08	3.29
1868	4.24	4.28	3.60	3.70	3.42	3.21	3.18	3.52	3.76	3.99	4.06	4.34	3.78
1869	4.44	4.37	4.63	4.26	3.93	3.40	3.02	2.76	2.87	3.23	3.35	3.63	3.66
1870	3.57	3.48	3.18	2.76	2.42	2.28	2.17	2.26	2.12	2.52	2.92	3.27	2.75
1871	3.12	3.20	2.60	2.40	2.05	2.01	1.98	2.21	2.88	3.57	3.62	4.21	2.82
1872	4.34	4.34	4.56	4.31	4.06	3.69	3.66	3.68	3.75	3.87	4.16	4.82	4.10
1873	4.82	4.78	4.47	3.90	3.34	2.71	2.75	2.65	2.84	2.90	3.13	3.17	3.45
1874	3.21	2.92	2.77	2.87	2.89	2.52	2.59	2.58	2.83	3.18	3.38	3.72	2.96
1875	3.92	3.99	3.93	3.57	3.01	2.77	2.80	2.63	2.70	2.85	3.06	3.25	3.21
1876	3.30	3.10	2.77	2.57	1.95	1.54	1.20	1.27	1.32	1.90	1.80	2.27	2.08
1877	2.41	2.40	2.40	2.02	2.13	2.06	2.09	2.21	2.42	2.41	2.53	2.59	2.31
1878	2.71	2.78	2.62	2.60	2.30	2.16	2.15	2.47	2.67	2.78	2.91	3.23	2.62
1879	3.54	3.53	3.49	3.50	3.37	3.30	3.21	3.40	3.52	3.74	3.96	3.93	3.54
1880	3.89	3.98	3.94	3.77	3.43	2.89	2.67	2.64	2.94	3.28	3.60	3.77	3.40
1881	3.76	3.55	3.26	2.35	2.84	2.61	2.64	2.64	2.87	2.54	2.71	2.81	2.88
1882	3.03	3.04	2.67	2.54	2.44	2.17	2.11	1.92	2.04	2.45	2.66	2.99	2.51
1883	3.25	3.21	3.12	2.91	2.43	2.07	1.47	1.50	1.69	1.91	2.30	2.44	2.36
1884	2.66	2.54	2.29	2.11	1.90	1.74	1.90	2.04	2.29	2.29	2.65	2.68	2.26
1885	2.67	2.44	2.48	2.29	1.93	1.72	1.63	1.42	1.56	1.70	2.00	2.29	2.01
1886	2.06	2.04	1.76	1.49	1.23	1.16	1.35	1.58	1.82	1.92	2.26	2.59	1.77
1887	2.67	2.30	2.14	2.19	1.99	1.86	1.92	2.06	2.40	2.85	3.18	3.30	2.41
1888	3.48	3.53	3.35	3.14	2.76	2.49	2.48	2.60	2.75	3.00	3.05	3.63	3.02
1889	3.65	3.68	3.70	3.69	3.61	3.15	2.97	3.21	3.38	3.63	3.98	4.16	3.57
1890	4.08	4.12	4.14	3.82	3.59	3.18	3.11	3.19	3.39	3.50	3.84	4.19	3.68
1891	4.21	4.45	4.26	3.95	3.85	3.70	3.87	3.94	4.17	4.53	4.93	4.99	4.24
1892	4.87	4.68	4.78	4.72	4.30	3.85	3.84	3.76	3.96	4.20	4.47	4.74	4.35
1893	4.75	4.61	4.50	4.04	3.74	3.41	3.39	3.56	3.88	4.02	4.41	4.48	4.07
1894	4.47	4.44	4.18	4.03	3.49	3.33	3.30	3.38	3.81	4.02	4.29	4.64	3.95
1895	4.82	4.93	4.96	4.76	4.60	4.55	4.66	4.78	5.05	5.42	5.64	5.75	4.99
Mean (36 years)	3.53	3.50	3.34	3.13	2.87	2.63	2.57	2.63	2.83	3.06	3.32	3.55	3.08
Mean (25 years, 1871–1895)	3.59	3.54	3.41	3.18	2.93	2.67	2.63	2.68	2.92	3.14	3.39	3.63	3.14

[1] Compiled by Assistant Alex. E. Kastl.

TABLE NO. 2.—*Lake Huron, at Point Aux Barques, Port Austin, and Sand Beach, Mich.; Lake Michigan, at Milwaukee, Wis.*

[Monthly mean of water levels below the plane of reference of United States Lake Survey (high water of 1838). The Lake Michigan record was used only from 1865 to 1870, inclusive, when there was no record kept on Lake Huron. Elevation of the plane of reference above mean tide at New York is 584.34 feet.]

Year.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Mean.
	Feet.	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*
1860*a*	2.02	2.07	1.93	1.96	1.91	1.67	1.58	1.66	1.85	2.23	2.35	2.05	1.99
1861*a*	2.86	2.82	2.68	2.48	1.86	1.52	1.40	1.29	1.37	1.59	1.90	2.03	1.98
1862*a*	2.41	2.42	2.51	2.30	1.93	1.81	1.76	1.78	2.00	1.72	2.04	2.33	2.08
1863*a*	2.49	2.64	2.69	2.62	2.30	2.17	2.26	2.25	2.39	2.65	2.69	2.92	2.51
1864*a*	3.06	3.10	3.10	2.90	2.47	2.46	2.51	2.62	2.94	(3.47)	(3.64)	(3.77)	3.00
1865*b*	4.13	4.04	3.87	3.38	3.22	3.18	2.75	2.73	2.85	3.09	3.65	3.96	3.40
1866*b*	4.22	4.46	4.41	3.96	3.78	3.49	3.23	3.17	3.32	3.43	3.52	3.78	3.73
1867*b*	3.80	3.75	3.57	3.28	3.06	2.75	2.60	2.67	2.94	3.27	3.73	4.08	3.29
1868*b*	4.24	4.28	3.60	3.70	3.42	3.21	3.18	3.52	3.76	3.99	4.06	4.34	3.78
1869*b*	4.44	4.37	4.63	4.26	3.93	3.40	3.02	2.76	2.87	3.23	3.35	3.63	3.66
1870*b*	3.57	3.48	3.18	2.76	2.42	2.28	2.17	2.26	2.12	2.52	2.92	3.27	2.75
1871*c*	(2.83)	(2.91)	(2.31)	(2.11)	(1.76)	(1.72)	(1.69)	2.29	2.61	3.11	3.32	3.69	2.53
1872*c*	3.86	4.06	(4.17)	4.14	3.74	3.34	3.24	3.27	3.37	3.49	3.79	4.08	3.71
1873*c*	4.25	4.28	4.21	3.80	3.30	2.90	2.70	2.69	2.86	2.89	2.99	3.15	3.34
1874*c*	3.13	2.99	2.85	3.00	2.95	2.61	2.45	2.56	2.72	2.96	3.23	3.48	2.91
1875*d*	3.69	3.75	3.71	3.52	3.17	2.86	2.67	2.70	2.66	2.85	2.96	3.23	3.15
1876*d*	3.11	3.13	3.00	2.72	2.12	1.63	1.19	1.25	1.36	1.76	1.91	2.10	2.11
1877*d*	2.39	2.40	2.47	2.39	2.22	2.26	2.08	2.18	2.45	2.59	2.64	2.69	2.40
1878*d*	2.79	2.96	2.79	2.86	2.46	2.29	2.25	2.35	2.64	2.63	2.82	3.02	2.66
1879*d*	3.32	3.56	3.60	3.57	3.44	3.30	3.26	3.39	3.47	3.71	3.83	3.85	3.53
1880*d*	3.80	3.86	3.87	3.86	3.46	2.97	2.60	2.77	2.88	3.24	3.36	3.56	3.36
1881*d*	3.09	3.30	3.29	3.27	2.95	2.78	2.63	2.80	2.96	2.71	2.58	2.75	2.98
1882*d*	2.90	3.13	2.99	2.77	2.60	2.37	2.23	2.17	2.29	2.52	2.77	2.92	2.64
1883*d*	3.12	3.17	3.13	3.12	2.55	2.13	1.65	1.45	1.77	2.10	1.99	2.10	2.36
1884*d*	2.29	2.44	2.40	2.09	1.87	1.81	1.73	1.85	2.20	2.04	2.39	2.65	2.15
1885*d*	2.38	2.47	2.47	2.36	1.96	1.67	1.61	1.46	1.56	1.79	1.98	2.18	1.99
1886*d*	2.18	2.11	1.92	1.63	1.30	1.21	1.37	1.52	1.70	1.83	2.10	2.42	1.77
1887*d*	2.59	2.40	2.19	2.28	2.08	1.96	1.88	2.09	2.44	2.66	3.11	3.40	2.42
1888*d*	3.51	3.60	3.43	3.29	2.85	2.55	2.52	2.48	2.78	3.07	3.25	3.46	3.07
1889*d*	3.60	3.68	3.70	3.77	3.63	3.30	3.04	3.10	3.27	3.64	3.98	4.14	3.57
1890*d*	4.07	4.19	4.21	4.07	3.76	3.33	3.14	3.14	3.41	3.62	3.82	4.12	3.74
1891*d*	4.32	4.43	4.46	4.13	3.89	3.94	3.91	4.01	4.20	4.57	4.88	4.94	4.31
1892*d*	4.92	4.98	4.92	4.84	4.71	4.18	3.89	3.81	3.98	4.19	4.52	4.76	4.48
1893*d*	5.01	5.06	4.98	4.60	3.97	3.22	3.50	3.64	3.93	4.14	4.37	4.57	4.25
1894*d*	4.62	4.61	4.46	4.23	3.83	3.53	3.38	3.65	3.84	4.08	4.27	4.57	4.09
1895*d*	4.82	4.94	4.93	4.83	4.66	4.59	4.62	4.71	4.84	5.13	5.52	5.76	4.95
Mean (36 years)	3.46	3.50	3.41	3.25	2.93	2.68	2.55	2.61	2.79	3.01	3.23	3.45	3.07
Mean (25 years, 1871-1895)	3.49	3.54	3.46	3.33	3.01	2.74	2.61	2.69	2.89	3.09	3.30	3.50	3.14

a Point Aux Barques, Mich.
b Milwaukee, Wis.
c Port Austin, Mich.
d Sand Beach, Mich.

NOTE.—Interpolated monthly means are indicated by parentheses, and are found for any year by taking the corresponding monthly means at Milwaukee, Wis., and correcting the same by the average difference between the observed monthly means at Point Aux Barques or Port Austin for that year and the corresponding observed monthly means at Milwaukee, Wis.

TABLE NO. 3.—*Lake Superior, at Superior, Wis., and Marquette, Mich.*

[Monthly mean of water level below the plane of reference of United States Lake Survey (high water of 1838). Elevation of the plane of reference above mean tide at New York City is 604.76 feet.]

Year.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Mean
	Feet.	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*
1860 a	(2.77)	(3.02)	(3.02)	2.52	2.29	2.12	2.16	2.11	2.13	2.09	2.26	(2.62)	2.43
1861 a	(2.73)	3.06	3.20	2.79	2.16	2.01	1.85	1.89	1.96	1.95	2.29	2.67	2.38
1862 a	3.02	3.21	3.18	3.12	2.44	2.45	2.48	2.31	2.19	2.26	2.59	2.86	2.68
1863 a	3.05	3.18	3.35	3.31	3.18	3.26	3.12	2.50	2.48	2.65	3.00	3.11	3.02
1864 a	3.40	3.61	3.54	3.52	3.36	3.21	3.12	3.11	2.96	3.22	3.41	3.56	3.34
1865 a	3.74	3.75	3.88	3.44	2.95	2.54	2.22	2.14	2.13	2.34	2.87	3.18	2.93
1866 a	3.47	3.68	3.68	3.23	2.98	2.79	2.50	2.27	2.54	2.52	2.85	2.74	2.94
1867 a	3.01	3.12	3.31	3.09	3.09	2.49	2.16	2.28	2.20	2.22	2.65	2.97	2.72
1868 a	3.13	3.72	3.36	3.17	2.77	2.86	2.64	2.72	2.59	2.62	2.46	2.89	2.91
1869 a	3.11	3.35	3.80	3.22	2.82	2.81	2.44	1.98	1.13	1.65	1.99	2.64	2.58
1870 a	2.89	3.10	3.09	2.99	2.66	2.85	2.66	2.66	2.49	2.65	2.83	3.76	2.89
1871 a	3.85	4.45	4.03	3.53	3.00	2.88	2.81	2.75	2.65	2.72	2.79	3.53	3.25
1872 b	3.85	3.96	4.08	4.18	3.53	3.15	2.88	2.71	2.55	2.65	2.80	3.10	3.29
1873 b	3.20	(3.65)	(3.62)	(3.61)	3.01	2.71	2.42	2.24	2.18	2.28	2.42	2.72	2.84
1874 b	(3.17)	3.19	3.23	3.13	3.06	2.86	2.48	2.30	2.29	2.23	2.41	2.72	2.76
1875 b	3.04	3.06	3.04	3.04	2.82	2.46	2.47	2.38	2.15	2.30	2.44	2.64	2.65
1876 b	2.84	3.05	3.14	3.11	2.57	1.89	1.50	1.39	1.50	1.83	1.99	2.27	2.26
1877 b	2.63	2.87	3.13	3.21	3.22	3.00	2.62	2.56	2.72	2.72	2.93	3.00	2.88
1878 b	3.12	3.00	3.77	3.80	3.53	3.25	3.18	3.30	3.47	3.40	3.60	3.92	3.45
1879 b	(3.82)	3.86	3.56	3.95	4.31	4.08	3.84	3.72	3.83	3.74	3.82	(4.12)	3.89
1880 b	(4.44)	(4.48)	(4.57)	(4.54)	(3.85)	3.02	2.87	2.88	2.88	2.93	2.99	3.25	3.56
1881 b	3.51	3.61	3.70	3.79	3.49	3.05	2.99	2.94	2.71	2.37	2.44	2.72	3.11
1882 b	3.07	3.32	3.43	3.51	3.35	3.33	2.88	2.76	2.72	2.89	2.91	3.10	3.11
1883 b	3.33	3.62	3.62	3.27	3.36	3.26	3.01	2.99	3.03	3.23	3.38	3.49	3.31
1884 b	(3.56)	(3.59)	(3.71)	4.00	3.78	3.58	3.44	3.43	3.16	2.80	2.90	3.11	3.42
1885 b	3.34	3.52	3.60	3.65	3.32	3.04	2.80	2.68	2.75	2.92	3.07	3.40	3.17
1886 b	3.60	3.73	3.79	3.70	3.45	3.31	3.24	3.33	3.35	3.25	3.40	3.54	3.47
1887 b	3.85	3.83	3.52	3.35	3.56	3.40	3.12	3.04	3.18	3.25	3.49	3.71	3.44
1888 b	3.82	3.81	3.88	3.88	3.41	2.63	2.44	2.30	2.35	2.44	2.58	2.93	3.04
1889 b	3.25	3.47	3.64	3.63	3.28	3.16	2.97	2.78	2.65	2.81	3.12	3.42	3.18
1890 b	3.56	3.69	3.93	3.96	3.75	3.30	3.00	2.85	2.72	2.75	2.96	3.32	3.32
1891 b	3.68	3.81	3.85	3.89	3.69	3.64	3.44	(3.37)	(3.43)	(3.38)	(3.49)	3.90	3.63
1892 b	3.90	4.18	4.31	4.30	3.97	3.59	3.56	3.44	3.39	3.49	3.66	3.94	3.81
1893 b	4.22	4.31	4.26	4.16	3.66	3.14	2.84	2.78	2.87	2.90	3.06	3.29	3.46
1894 b	3.47	3.65	3.56	3.41	2.63	2.41	2.35	2.22	2.30	2.28	2.33	2.52	2.76
1895 b	2.82	3.04	3.21	3.31	2.94	2.62	2.42	2.37	2.23	2.18	2.47	2.80	2.70
Mean (36 years)	3.37	3.54	3.60	3.51	3.20	2.95	2.75	2.65	2.61	2.66	2.85	3.15	3.07
Mean (25 years, 1871–1895)	3.48	3.63	3.69	3.68	3.38	3.07	2.86	2.78	2.76	2.79	2.94	3.22	3.19

a Superior, Wis. *b* Marquette, Mich.

NOTE.—Interpolated monthly means are indicated by parentheses, and for the Superior, Wis., record are found for any year by taking the mean of the monthly means for each month in the ten-year series, 1862 to 1871, and correcting the same by the average difference between the observed monthly means for that year and the corresponding means of the monthly means in the ten-year series.

This method was adopted because there are no corresponding records at other places.

"There is an uncertainty of 0.4 foot in the elevation of the zero of the gauge at Superior, Wis., for the years 1860–1871 (see Report Chief of Engineers, U. S. A., 1873, pp. 157, 159), and the possible alternative would make the water surface 0.4 foot lower than is given in Table No. 3." (From letter of Maj. Clinton B. Sears, Corps of Engineers, U. S. A., dated June 30, 1896.)

The Superior, Wis., record here used is that finally adopted by the United States Lake Survey in 1876.

Interpolated monthly means, indicated by parentheses, for the Marquette record are found for any year by taking the corresponding monthly means at Sault Ste. Marie, Mich., and correcting the same by the average difference between the observed monthly means at Marquette for that year and the corresponding observed monthly means at Sault Ste. Marie, Mich.

TABLE NO. 4.—*St. Marys River above the locks at Sault Ste. Marie, Mich.*

[Monthly mean of water levels below the plane of reference of United States Lake Survey (high water of 1838). Elevation of the plane of reference above mean tide at New York City is 604.18 feet.]

Year.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Mean.
	Feet.	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*
1871	3.60	3.75	4.02	3.89	3.31	2.90	2.73	2.81	2.75	2.95	3.18	3.57	3.29
1872	3.81	3.90	4.13	4.18	3.29	3.11	2.72	2.39	2.33	2.48	2.62	3.08	3.17
1873	3.47	3.65	3.62	3.61	3.05	2.85	2.35	2.15	2.09	2.25	2.33	2.64	2.84
1874	3.20	3.45	3.56	3.68	3.15	2.83	2.45	2.40	2.41	2.28	2.41	2.61	2.88
1875	3.06	3.31	3.36	3.11	2.80	2.52	2.41	2.40	2.12	2.25	2.53	3.09	2.75
1876	3.12	3.17	3.37	3.39	2.66	2.01	1.61	1.57	1.53	1.87	2.15	2.63	2.42
1877	2.92	2.90	3.01	3.14	3.20	2.91	2.58	2.47	2.71	2.07	2.91	3.07	2.87
1878	3.29	3.55	3.64	3.66	3.61	3.13	3.02	3.06	3.35	3.23	3.32	3.54	3.37
1879	3.94	4.34	4.58	4.45	4.06	3.93	3.70	3.61	3.69	3.66	3.84	4.24	4.01
1880	4.43	4.47	4.56	4.53	3.84	3.03	2.80	2.93	2.77	2.99	2.97	3.24	3.55
1881	3.56	3.66	3.63	3.75	3.32	3.09	2.89	2.97	2.79	2.32	2.43	2.81	3.10
1882	3.29	3.49	3.59	3.63	3.24	3.14	2.80	2.71	2.79	2.86	2.92	3.21	3.14
1883	3.61	3.72	3.70	3.64	3.63	3.29	3.09	2.74	3.02	3.18	3.33	3.53	3.37
1884	3.65	3.68	3.80	4.08	3.61	3.62	3.38	3.34	3.28	3.19	3.14	3.33	3.51
1885	3.54	3.63	3.76	3.94	3.39	3.02	2.84	2.63	2.88	3.03	3.11	3.41	3.27
1886	3.75	3.92	3.92	3.94	3.46	3.30	3.11	2.96	3.13	3.15	3.16	3.57	3.45
1887	3.82	3.92	3.99	4.12	3.76	3.32	2.95	3.06	3.21	3.03	3.26	3.67	3.51
1888	3.82	4.17	4.12	4.13	3.52	2.68	2.52	2.52	2.60	2.62	2.82	3.16	3.22
1889	3.43	3.72	3.70	3.71	3.14	2.97	2.70	2.69	2.70	2.84	3.14	3.53	3.19
1890	3.48	4.03	4.04	4.10	3.64	3.02	2.70	2.79	2.90	2.64	3.10	3.41	3.32
1891	4.10	3.99	4.13	3.96	3.53	3.58	3.47	3.46	3.52	3.47	3.58	3.84	3.72
1892	3.95	4.30	4.48	4.33	3.82	3.46	3.32	3.31	3.25	3.36	3.64	3.92	3.76
1893	4.17	4.37	4.36	4.11	3.54	3.00	2.81	2.72	2.85	2.91	2.97	3.50	3.44
1894	3.73	3.81	3.92	3.53	2.56	2.32	2.18	2.17	2.30	2.26	2.36	2.66	2.82
1895	2.96	3.09	3.30	3.32	2.91	2.53	2.29	2.27	2.10	1.98	2.50	2.71	2.66
Mean (25 years).	3.59	3.76	3.85	3.83	3.36	3.02	2.78	2.73	2.76	2.78	2.95	3.28	3.23

NOTE.—A table giving elevations above mean tide at New York has been compiled by the United States Engineer office at Detroit and contains many minor variations from the above. Most of these are small, and such as may be due to a different method of reduction, and only six exceed 0.10, the largest being 0.22.

TABLE NO. 5.—*St. Marys River below the locks at Sault Ste. Marie, Mich.*

[Monthly mean of water levels above a plane of reference which is 0.58 feet below the plane of mean tide at New York City.]

Year.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Mean.
	Feet.	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*
1871	584.26	584.26	584.20	583.81	584.23	584.45	584.70	584.60	584.28	583.98	583.44	584.04	584.19
1872	583.88	583.70	583.76	583.37	583.29	583.63	583.91	584.15	584.27	584.11	584.00	584.53	583.88
1873	585.10	585.54	585.23	584.31	583.69	584.06	584.48	584.74	584.75	584.76	584.43	584.31	584.62
1874	586.04	585.27	585.10	584.47	583.79	584.14	584.41	584.65	584.66	584.62	584.38	584.45	584.66
1875	586.35	585.88	585.89	584.92	583.96	584.33	584.47	584.67	584.81	584.68	584.62	584.95	584.96
1876	584.92	584.91	585.36	585.19	584.95	585.47	585.91	586.04	585.91	585.54	585.23	586.19	585.47
1877	585.20	584.78	584.60	584.28	584.13	584.33	584.67	584.75	584.51	584.46	584.22	584.12	584.51
1878	583.98	583.77	583.55	583.52	583.79	584.06	584.24	584.13	583.94	584.02	583.52	583.73	583.85
1879	584.30	583.66	583.52	582.94	582.70	582.82	583.14	583.25	583.16	583.13	582.85	582.99	583.20
1880	583.14	583.30	583.28	582.79	583.12	583.88	584.25	584.16	584.12	584.08	583.94	584.21	583.69
1881	584.29	584.38	584.36	583.61	583.55	583.87	584.06	584.05	584.17	584.49	584.56	584.16	584.13
1882	584.71	584.51	584.24	583.78	583.74	584.02	584.40	584.53	584.47	584.28	584.06	583.92	584.22
1883	584.52	584.61	584.59	583.84	583.56	584.07	584.55	584.71	584.54	584.33	584.17	584.07	584.30
1884	584.06	584.13	584.43	583.72	583.92	584.09	584.12	584.19	584.27	584.48	584.24	584.13	584.15
1885	584.92	585.51	585.39	584.87	584.38	584.49	584.67	584.77	584.82	584.54	584.27	584.01	584.72
1886	584.28	584.35	584.47	584.47	584.47	584.60	584.66	584.57	584.54	584.47	584.22	583.99	584.43
1887	583.91	583.94	584.03	584.02	583.89	584.02	584.28	584.19	583.98	583.80	583.35	583.15	583.88
1888	583.36	583.36	583.64	583.76	583.50	583.85	583.85	583.83	583.93	583.92	583.64	583.51	583.68
1889	583.76	583.57	583.42	582.74	583.00	583.39	583.71	583.82	583.81	583.43	582.95	582.68	583.36
1890	583.99	583.56	583.47	582.85	582.73	583.18	583.55	583.58	583.56	583.38	583.21	582.98	583.34
1891	583.10	583.10	583.01	582.74	582.50	582.54	582.76	582.79	582.62	582.52	582.35	582.21	582.69
1892	582.52	582.47	582.48	581.79	582.04	582.53	583.00	583.12	583.08	582.71	582.25	581.81	582.48
1893	581.99	582.05	582.16	582.11	582.26	582.88	583.09	582.93	582.81	582.82	582.72	582.51	582.53
1894	582.65	582.62	582.79	582.39	582.87	583.07	583.18	583.13	583.02	582.93	582.82	582.59	582.84
1895	583.16	583.56	583.07	582.26	582.01	582.28	582.42	582.53	582.64	582.66	582.03	581.89	582.54
Mean (25 years).	584.10	584.03	584.00	583.54	583.45	583.76	584.02	584.07	584.03	583.93	583.66	583.65	583.85

TABLE NO. 6.—*Detroit River at Light-House Depot at Detroit, Mich.*

[Monthly mean of water levels below the plane of reference of United States Lake Survey (high water of 1838). Elevation of the plane of reference above mean tide at New York City is 577.62 feet.]

Year.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Mean.
	Feet.	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*
1867	(2.38)	(2.70)	(2.30)	(1.98)	1.70	1.35	1.39	1.60	1.91	2.29	2.78	2.98	2.11
1868	(3.58)	(3.96)	(3.37)	2.59	2.15	1.85	1.90	2.22	2.47	2.86	3.08	3.12	2.76
1869	(3.67)	(3.74)	(3.26)	2.91	2.93	2.22	1.77	1.74	1.95	2.41	2.78	(2.67)	2.67
1870	(2.26)	(2.03)	(2.26)	2.03	1.63	1.55	1.29	1.35	1.57	1.91	2.22	2.30	1.87
1871	(2.32)	(2.65)	1.73	1.81	1.57	1.54	1.46	1.64	1.92	2.49	2.68	(3.11)	2.08
1872	(2.98)	(3.22)	(3.31)	2.98	2.75	2.34	2.28	2.35	2.55	2.71	3.14	3.35	2.83
1873	3.66	3.46	3.40	2.23	1.97	1.85	1.72	1.75	2.10	2.33	2.47	2.19	2.43
1874	2.43	3.14	2.33	1.88	1.94	1.78	1.58	1.68	2.04	2.38	2.83	2.87	2.24
1875	2.76	2.89	2.78	2.81	2.40	2.20	2.02	1.97	2.11	2.47	2.48	2.53	2.45
1876	2.52	2.20	1.94	1.30	.93	.79	.57	.74	.95	1.45	1.48	*a*1.72	1.38
1877	1.01	*a*2.38	3.85	2.36	2.11	1.76	1.56	1.61	1.76	2.04	2.09	2.14	2.06
1878	1.96	*b*3.64	2.33	1.64	1.47	1.42	1.33	1.55	1.65	1.96	2.13	1.76	1.90
1879	2.58	3.68	2.89	2.49	2.38	2.20	2.10	2.31	2.50	2.79	3.10	2.87	2.66
1880	2.59	3.02	2.60	2.44	2.26	1.88	1.72	1.84	2.09	2.44	2.61	1.97	2.29
1881	3.51	3.07	3.05	2.44	2.09	1.80	1.79	1.91	2.19	(2.44)	(2.62)	(2.41)	2.44
Mean (15 years)	2.68	3.05	2.76	2.26	2.02	1.77	1.63	1.75	1.98	2.33	2.57	2.53	2.28

a River dammed up by ice below the city.
b At Port Huron the St. Clair River was dammed up by ice.

NOTE.—Interpolated monthly means are indicated by parentheses, and are found for any year by taking the corresponding monthly means at Cleveland, Ohio, and correcting the same by the average difference between the observed monthly means at Detroit for that year and the corresponding monthly means at Cleveland, Ohio.

TABLE NO. 7.—*Lake Erie at Cleveland, Ohio.*

[Monthly mean of water levels below the plane of reference of United States Lake Survey (high water of 1838). Elevation of the plane of reference above mean tide at New York is 575.20 feet.]

Year.	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Mean.
	Feet.	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*
1860	1.85	2.21	1.81	1.11	0.90	0.93	1.19	1.35	1.69	1.99	2.08	2.24	1.61
1861	2.50	2.78	2.34	1.30	.87	.80	1.05	1.01	1.19	1.42	1.44	1.67	1.53
1862	1.68	1.97	1.83	.93	.69	.69	.72	1.10	1.41	1.79	2.13	2.10	1.42
1863	1.65	1.36	1.42	1.30	1.12	1.26	1.38	1.46	1.85	2.29	2.70	2.73	1.71
1864	3.02	2.87	2.66	2.16	1.46	1.51	1.77	2.04	2.26	2.57	2.74	2.67	2.31
1865	3.10	3.68	3.36	2.64	2.06	2.08	2.12	2.20	2.24	2.54	2.92	3.06	2.67
1866	3.33	3.49	3.10	2.52	2.30	2.04	1.93	2.18	2.24	2.25	2.49	2.48	2.53
1867	2.77	3.09	2.69	2.37	1.85	1.54	1.73	2.04	2.43	2.77	3.27	3.49	2.50
1868	3.69	4.07	3.48	2.65	2.20	1.81	1.84	2.36	2.63	3.08	3.24	3.45	2.88
1869	3.46	3.53	3.05	2.75	2.20	1.81	1.53	1.63	1.90	2.35	2.81	2.46	2.46
1870	2.22	1.99	2.22	1.57	1.36	1.39	1.35	1.40	1.65	2.03	2.33	2.45	1.83
1871	2.66	2.99	2.54	2.06	1.79	1.76	1.78	1.99	2.16	2.83	3.01	3.45	2.42
1872	3.53	3.77	3.86	3.66	3.22	2.85	2.86	2.89	3.12	3.29	3.62	3.85	3.38
1873	3.95	3.94	3.87	2.59	1.92	1.84	1.86	1.92	2.32	2.62	2.82	2.45	2.67
1874	2.06	2.01	1.98	1.81	1.72	1.65	1.62	1.78	2.24	2.68	3.10	3.31	2.16
1875	3.54	3.71	3.57	3.17	2.70	2.27	2.14	2.15	2.29	2.78	2.93	2.71	2.83
1876	2.75	2.19	1.54	1.02	.70	.59	.70	1.00	1.17	1.70	1.62	1.96	1.41
1877	(2.36)	2.52	2.75	2.32	2.07	1.99	1.75	1.89	1.97	2.37	2.45	2.37	2.23
1878	2.29	2.15	2.02	1.60	1.34	1.34	1.34	1.58	1.71	2.06	2.26	2.18	1.82
1879	2.60	2.74	2.71	2.35	2.20	2.11	2.08	2.30	2.63	2.86	3.33	3.07	2.58
1880	2.57	2.53	2.39	2.23	1.96	1.85	1.76	2.00	2.23	(2.67)	(2.75)	(3.09)	2.34
1881	(3.50)	(3.39)	(3.07)	2.37	1.97	1.73	1.78	2.10	2.45	2.50	2.68	2.47	2.50
1882	2.00	2.00	1.56	1.33	1.13	.98	1.05	1.19	1.46	1.91	2.23	2.74	1.63
1883	2.83	2.62	2.43	2.31	1.85	1.15	.95	1.01	1.32	1.64	2.02	1.99	1.84
1884	2.32	2.06	1.87	1.32	1.05	.97	1.19	1.35	1.78	2.11	2.59	2.66	1.77
1885	2.84	3.05	3.19	2.37	1.64	1.13	1.17	1.16	1.31	1.41	1.53	1.58	1.87
1886	1.56	2.29	2.48	1.60	1.30	1.20	1.22	1.43	1.67	1.90	2.31	2.26	1.77
1887	2.49	2.07	1.26	1.24	1.06	1.03	1.27	1.59	1.82	2.41	2.68	2.66	1.80
1888	2.84	3.11	3.01	2.38	2.13	2.00	1.85	1.95	2.39	2.76	2.70	2.82	2.50
1889	2.80	2.96	3.12	2.77	2.59	2.16	1.96	2.27	2.66	3.08	3.35	3.09	2.73
1890	2.73	2.44	2.32	1.88	1.49	1.12	1.[illegible]	1.94	2.13	2.32	2.35	2.58	2.06
1891	2.80	2.82	2.36	2.49	2.67	2.53	2.63	2.90	3.08	3.46	3.90	3.83	2.96
1892	3.80	4.01	3.97	3.41	2.61	1.85	1.73	2.08	2.40	2.96	3.29	3.56	2.97
1893	3.94	3.86	3.64	2.91	2.07	1.88	2.16	2.50	2.88	3.23	3.63	3.55	3.02
1894	3.27	3.39	3.36	2.96	2.57	2.26	2.38	2.75	2.92	3.24	3.48	3.55	3.01
1895	3.88	4.11	4.10	3.85	3.63	3.54	3.65	3.73	3.83	4.31	4.41	4.25	3.94
Mean (36 years)	2.81	2.88	2.69	2.20	1.84	1.66	1.69	1.90	2.15	2.51	2.76	2.80	2.32
Mean (25 years, 1871–1895)	2.88	2.91	2.76	2.32	1.96	1.75	1.78	1.98	2.24	2.60	2.84	2.88	2.41

NOTE.—Interpolated monthly means are indicated by parentheses, and are found for any year by taking the corresponding monthly means at Erie, Pa., and correcting the same by the average difference between the observed monthly means at Cleveland for that year and the corresponding observed monthly means at Erie, Pa.

TABLE NO. 8.—*Lake Erie at Erie, Pa.*

[Monthly mean of water levels below the plane of reference of United States Lake Survey (high water of 1838). Elevation of the plane of reference above mean tide at New York City is 575.20 feet.]

Year.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Mean.
	Feet.	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*
1860	.....	.....	.....	.....	.....	.....	.....	1.20	1.49	1.93	1.84	2.07	.....
1861	.....	.....	.....	1.35	0.83	0.78	0.96	1.08	1.19	1.30	1.45	1.65	.....
1862	.....	.....	.....	1.16	.76	.83	.78	1.16	1.55	1.76	2.03	2.01	.....
1863	.....	.....	.....	.....	.....	1.25	1.76	1.93	2.53	2.91	2.97	3.05	.....
1864	.....	.....	.....	2.10	1.40	1.37	1.78	2.17	2.54	2.60	2.40	2.31	.....
1865	.....	.....	.....	2.49	2.07	1.98	2.04	2.04	2.07	2.38	2.53	2.77	.....
1866	.....	.....	.....	2.37	2.18	1.97	1.80	1.92	1.97	2.00	2.31	2.16	.....
1867	.....	.....	.....	2.13	1.85	1.78	2.14	2.35	2.33	2.67	2.85	2.87	.....
1868	.....	.....	.....	2.46	2.31	1.84	1.69	2.13	2.39	2.84	3.14	2.84	.....
1869	.....	.....	.....	3.11	2.42	1.91	1.43	1.53	1.74	1.96	2.44	2.13	.....
1870	1.51	1.56	1.63	1.66	1.56	1.53	1.39	1.38	1.75	1.88	2.20	2.33	1.70
1871	2.25	2.26	2.21	1.98	1.73	1.66	1.63	1.98	2.10	2.58	2.84	2.88	2.17
1872	3.02	(3.58)	3.61	3.59	3.16	2.77	2.68	2.73	2.90	3.27	3.31	3.60	3.19
1873	3.72	3.94	3.61	2.55	1.89	1.88	1.65	1.97	2.22	2.47	2.53	2.16	2.55
1874	1.90	1.95	1.67	1.99	1.78	1.59	1.63	1.86	2.15	2.32	3.22	2.85	2.08
1875	3.02	(3.51)	3.34	2.97	2.37	2.21	2.11	2.14	2.18	2.43	2.74	2.59	2.63
1876	2.34	1.82	1.42	.83	.55	.51	.54	.90	1.19	1.40	1.48	1.69	1.22
1877	2.30	2.52	2.55	2.34	2.01	1.98	1.71	1.83	2.03	2.31	2.22	2.26	2.17
1878	2.23	2.20	2.05	1.59	1.28	1.32	1.30	1.54	1.68	1.91	2.11	1.54	1.73
1879	2.21	2.65	2.56	2.17	2.12	2.02	2.03	2.30	2.54	2.69	3.09	2.99	2.45
1880	2.53	2.11	2.24	2.00	1.83	1.75	1.70	2.01	2.14	2.53	2.61	2.95	2.20
1881	3.39	3.28	2.96	2.26	1.98	1.84	1.66	2.12	2.43	2.40	2.18	2.23	2.39
1882	1.73	1.84	1.44	1.27	1.15	.77	.92	1.15	1.50	1.78	2.15	2.23	1.49
1883	2.48	2.30	2.21	2.16	1.69	.91	.70	.91	1.36	1.57	1.50	1.66	1.62
1884	1.90	1.97	1.70	1.20	.98	.97	.90	1.05	1.48	1.74	2.02	2.16	1.50
1885	2.37	2.75	2.92	2.12	1.37	.89	.90	.90	1.00	1.20	1.11	1.00	1.54
1886	1.20	1.90	2.30	1.50	1.00	.90	1.12	1.66	1.89	2.07	2.11	2.24	1.66
1887	2.43	1.85	1.49	1.51	1.30	1.20	1.42	1.90	2.14	2.37	2.75	2.74	1.93
1888	2.84	3.33	3.24	2.58	2.41	2.11	1.90	1.97	2.38	2.60	2.60	2.60	2.55
1889	2.67	2.81	3.12	2.79	2.66	2.13	2.04	2.35	2.69	3.16	3.18	2.93	2.71
1890	2.33	2.30	2.10	1.86	1.46	1.17	1.55	2.01	2.31	2.37	2.23	2.40	2.01
1891	2.78	2.72	2.48	2.51	2.70	2.56	2.56	2.85	3.06	3.39	3.60	3.48	2.89
1892	3.43	3.97	3.80	3.36	2.56	1.84	1.64	2.02	2.37	2.76	3.11	3.21	2.84
1893	3.73	3.76	3.49	2.84	1.90	1.74	1.96	2.45	2.73	2.90	3.11	3.11	2.81
1894	3.01	3.20	3.21	2.96	2.53	2.04	2.24	2.68	2.90	3.00	3.15	3.33	2.85
1895	3.41	3.82	4.01	3.85	3.55	3.49	3.59	3.64	3.67	4.01	4.25	4.06	3.78

NOTE.—Interpolated monthly means are indicated by parentheses, and are found for any year by taking the corresponding monthly means at Cleveland, Ohio, and correcting the same by the average difference between the observed monthly means at Erie for that year and the corresponding observed monthly means at Cleveland, Ohio.

TABLE NO. 9.—*Lake Ontario at Oswego, N. Y.*

[Monthly mean of water levels above the zero of the United States Engineer gauge, the elevation of which zero is 244.21 feet above mean tide at New York City.]

Year.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Mean.
	Feet.	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*
1860	2.46	2.60	2.65	2.68	2.91	3.45	3.70	3.14	2.74	2.55	2.63	2.61	2.84
1861	2.32	2.44	2.89	3.11	4.06	4.42	4.20	3.95	3.48	3.69	3.70	3.49	3.48
1862	2.99	2.57	3.06	3.96	4.76	4.50	4.60	4.14	3.51	2.96	2.61	2.50	3.51
1863	2.65	2.71	2.79	3.51	3.91	4.06	3.65	3.19	2.81	2.62	2.44	2.45	3.07
1864	2.21	2.05	2.14	2.71	3.70	4.00	3.68	3.22	2.69	2.46	2.43	2.53	2.82
1865	2.96	3.11	3.26	3.34	3.50	3.54	3.39	2.78	2.17	1.95	1.70	1.54	2.77
1866	1.34	1.35	1.36	1.84	1.90	1.80	2.72	2.62	2.53	2.40	2.16	2.08	2.01
1867	1.83	1.80	2.50	3.40	4.09	4.36	3.99	3.36	2.86	2.21	1.47	.71	2.72
1868	.39	.49	.76	1.40	2.00	2.42	2.30	2.01	1.82	1.23	1.08	1.25	1.43
1869	1.10	1.22	1.44	1.97	2.63	2.85	3.17	3.23	3.05	2.96	2.56	2.73	2.41
1870	3.14	3.29	3.29	4.23	4.83	4.51	4.19	3.85	3.16	2.83	2.26	2.01	3.47
1871	1.94	1.77	1.98	2.58	3.00	2.94	2.78	2.34	2.00	1.50	1.09	.78	2.06
1872	.61	.39	.23	.72	.84	1.17	1.23	1.07	.78	.62	.57	.23	.71
1873	.19	.26	.38	2.34	2.88	2.80	2.76	2.48	2.06	1.61	1.48	1.67	1.74
1874	2.23	2.63	3.18	3.07	3.05	3.14	3.09	2.86	2.22	1.82	1.25	.91	2.45
1875	.61	.26	.52	1.32	1.59	1.75	1.78	1.64	1.43	1.15	.96	.78	1.15
1876	1.19	1.85	2.40	3.38	3.96	4.18	4.25	3.79	3.18	2.84	2.48	2.30	2.98
1877	1.77	1.50	1.65	2.34	2.41	2.31	2.35	2.08	1.65	1.22	1.13	1.26	1.81
1878	1.36	1.57	2.27	2.52	2.86	2.85	2.81	2.73	(2.47)	2.21	2.09	2.90	2.39
1879	2.69	2.33	2.18	2.59	2.68	2.71	2.55	2.20	1.78	1.34	.95	.98	2.08
1880	1.20	1.48	1.82	2.00	2.15	2.39	2.40	1.97	1.60	1.19	1.15	.98	1.69
1881	.62	.61	1.27	1.69	1.87	2.09	2.16	1.84	1.28	1.06	1.06	1.06	1.38
1882	1.61	1.78	2.38	2.71	2.90	3.41	3.40	3.07	2.69	2.18	1.76	1.47	2.45
1883	1.20	1.26	1.50	2.02	2.67	3.37	3.90	3.72	3.24	2.80	2.57	2.43	2.56
1884	2.39	2.76	3.44	4.05	4.07	3.97	3.76	3.53	3.10	2.68	2.18	2.03	3.16
1885	2.02	1.75	1.47	2.15	2.95	3.32	3.46	3.31	3.09	2.90	2.95	3.12	2.71
1886	3.48	3.55	3.69	4.31	4.52	4.32	3.92	3.48	3.12	2.83	2.39	2.30	3.49
1887	2.05	2.80	3.31	3.52	4.08	4.04	3.76	3.25	2.64	2.25	1.90	1.63	2.94
1888	1.32	1.18	1.42	2.05	2.12	2.16	2.22	2.12	1.73	1.37	1.30	1.29	1.69
1889	1.50	1.64	1.81	2.05	2.20	2.51	2.70	2.45	1.89	1.45	1.05	1.62	1.91
1890	2.13	2.48	2.81	3.05	3.41	4.04	3.87	3.20	2.85	2.52	2.60	2.39	2.95
1891	2.07	2.33	2.87	3.35	3.13	2.71	2.43	1.99	1.56	.92	.32	.29	2.00
1892	.39	.36	.49	1.07	1.13	1.69	2.20	2.12	1.92	1.48	1.21	1.08	1.26
1893	.75	.64	1.12	1.87	3.03	3.25	2.99	2.45	2.18	1.66	1.25	1.10	1.86
1894	1.44	1.62	1.92	1.97	2.15	2.68	2.48	1.90	1.39	1.14	.81	.46	1.66
1895	.37	.31	.21	.76	.88	.76	.47	+.22	—.12	—.46	—.71	—.68	.17
Mean (36 years)	1.68	1.74	2.01	2.55	2.91	3.07	3.04	2.70	2.29	1.95	1.69	1.62	2.27
Mean (25 years, 1871–1895)	1.49	1.56	1.85	2.38	2.66	2.82	2.79	2.47	2.07	1.69	1.43	1.38	2.05

TABLE NO. 10.—*Lake Ontario at Charlotte, N. Y.*

[Monthly mean of water levels below the plane of reference of United States Lake Survey (high water of 1838). Elevation of the plane of reference above mean tide at New York City is 249.04 feet.]

Year.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Mean
	Feet.	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*
1860	2.40	2.57	2.46	2.44	2.20	2.01	1.89	1.90	2.31	2.57	2.49	2.48	2.31
1861	2.70	2.69	2.25	1.71	.94	.70	.69	.98	1.44	1.29	1.38	1.58	1.53
1862	1.94	2.20	2.09	1.23	.40	.55	.66	.99	1.52	2.02	2.39	2.53	1.54
1863	2.46	2.27	2.10	1.51	1.01	1.01	1.25	1.56	2.11	2.54	2.73	2.72	1.94
1864	2.88	2.90	2.83	2.29	1.24	.91	1.31	1.69	2.22	2.51	2.42	2.20	2.12
1865	2.47	2.81	2.40	1.77	1.51	1.54	1.74	2.23	2.59	2.94	3.26	3.34	2.38
1866	3.53	3.76	3.45	3.10	2.64	1.90	2.13	2.35	2.49	2.81	2.59	2.13	2.72
1867	2.19	2.21	2.08	1.67	.88	.58	.90	.89	1.00	1.63	3.42	3.64	1.77
1868	3.82	4.18	3.82	3.16	2.63	2.28	2.41	2.62	2.85	3.55	3.44	3.46	3.19
1869	3.60	3.47	3.28	2.54	1.95	1.78	1.51	1.56	1.71	2.01	2.42	2.27	2.34
1870	1.74	1.59	1.66	.63	—.05	.17	.44	.89	1.49	1.84	2.26	2.46	1.26
1871	2.68	2.90	2.61	1.95	1.66	1.73	1.90	2.34	2.68	3.25	3.68	4.20	2.63
1872	4.35	4.55	4.68	4.26	4.02	3.70	3.64	3.79	4.04	4.14	4.25	4.44	4.16
1873	4.51	4.60	4.43	2.75	2.07	2.02	2.08	2.32	2.76	3.12	3.28	3.15	3.09
1874	2.68	2.34	1.90	1.79	1.66	1.70	1.59	1.84	2.34	2.95	3.48	3.78	2.34
1875	4.13	4.46	4.30	3.52	3.17	3.12	2.97	3.15	3.38	3.63	3.81	3.91	3.63
1876	3.50	2.87	2.28	1.36	.68	.56	.54	.96	1.62	1.96	2.30	2.56	1.77
1877	2.96	3.19	3.07	2.46	2.31	2.49	2.46	2.72	3.13	3.52	3.66	3.51	2.96
1878	3.37	3.13	2.61	2.21	1.88	1.88	1.92	2.02	2.17	2.60	2.63	1.95	2.36
1879	2.18	2.52	2.50	2.24	2.08	2.05	2.24	2.61	3.01	3.45	3.84	3.82	2.71
1880	3.60	3.30	2.98	2.75	2.54	2.40	2.47	2.84	3.15	3.63	3.73	3.93	3.11
1881	4.23	4.14	3.57	3.20	2.90	2.70	2.65	2.98	3.42	3.74	3.74	3.76	3.42
1882	3.23	3.03	2.45	2.14	1.86	1.36	1.35	1.72	2.10	2.57	3.05	3.38	2.35
1883	3.59	3.52	3.30	2.74	2.12	1.36	1.13	1.29	1.72	2.14	2.40	2.49	2.32
1884	2.55	2.13	2.04	.96	.82	.93	1.07	1.33	1.83	2.23	2.83	2.89	1.80
1885	2.92	3.21	3.43	2.70	1.91	1.57	1.43	1.62	1.81	2.72	2.69	2.12	2.34
1886	1.79	1.79	1.79	.82	.66	.73	1.06	1.48	1.90	2.26	2.55	2.63	1.62
1887	2.83	2.15	1.71	1.43	.90	.91	1.19	1.68	2.28	2.76	3.25	3.40	2.04
1888	3.52	3.71	3.49	2.99	2.83	2.73	2.80	2.96	3.19	3.53	3.66	3.70	3.26
1889	3.58	3.28	3.21	3.04	2.79	2.35	2.21	2.46	3.00	3.32	3.65	3.43	3.03
1890	2.82	2.51	2.52	1.98	1.60	1.03	1.08	1.65	2.12	2.35	2.40	2.63	2.06
1891	2.95	2.87	2.28	1.71	1.78	2.19	2.50	2.87	3.29	3.92	4.62	4.61	2.97
1892	4.40	4.47	4.49	4.07	3.83	3.25	2.72	2.78	3.07	3.49	3.81	3.90	3.69
1893	3.91	4.23	3.85	3.16	1.93	1.66	1.90	2.40	2.76	3.20	3.70	3.89	3.05
1894	3.54	3.32	2.95	2.88	2.72	2.24	2.45	3.05	3.53	3.83	4.10	4.43	3.25
1895	4.42	4.55	4.57	4.23	4.01	4.19	4.44	4.71	4.92	5.32	5.55	5.45	4.70
Mean (36 years)	3.17	3.15	2.93	2.37	1.95	1.79	1.85	2.15	2.53	2.92	3.21	3.24	2.60
Mean (25 years, 1871–1895)	3.37	3.31	3.08	2.53	2.19	2.03	2.07	2.88	2.77	3.19	3.46	3.52	2.83

NOTE.—This record is less satisfactory than the one for Oswego, on account of uncertainties of a minor character respecting plane of reference.

TABLE NO. 11.—*St. Lawrence River at Valleyfield, Province of Quebec.*

[Monthly mean of water levels above the upper miter sill of Lock No. 14 of the Beauharnois Canal. Elevation of miter sill is 142.52 feet above mean tide at New York City.]

Year.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Mean.
	Feet.	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*
1860	12.84	12.45	12.56	12.48	12.50	12.64	12.71	12.66	12.55	12.44	12.72	12.82	12.61
1861	12.81	12.44	12.83	13.20	13.53	13.52	13.49	13.14	12.85	13.11	13.01	12.94	13.07
1862	13.25	12.92	12.62	13.40	13.76	13.31	13.21	13.08	12.77	12.48	12.38	12.38	12.96
1863	12.38	12.44	12.37	13.14	13.22	13.16	12.90	12.70	12.42	12.17	12.18	12.23	12.61
1864	12.06	12.06	12.05	12.50	13.09	13.10	12.89	12.55	12.34	12.27	12.30	12.59	12.48
1865	12.64	12.17	12.55	13.03	12.90	12.87	12.73	12.32	11.97	11.74	11.62	11.77	12.36
1866	11.85	11.56	11.51	12.17	12.20	12.47	12.35	12.38	12.40	12.10	12.23	12.55	12.15
1867	13.10	12.52	12.53	13.04	13.49	13.29	12.91	12.54	12.13	11.69	11.48	11.39	12.51
1868	11.68	11.04	11.33	11.55	11.74	12.07	11.92	11.81	11.63	11.39	11.37	11.72	11.60
1869	11.81	11.28	11.06	12.40	12.66	12.41	12.60	12.49	12.41	12.51	12.17	12.21	12.17
1870	12.83	12.98	12.36	13.31	13.42	13.28	13.17	12.94	12.54	12.44	12.28	12.19	12.81
1871	12.31	12.09	12.28	12.48	12.66	12.56	12.39	12.04	11.87	11.51	11.33	11.43	12.07
1872	11.12	10.36	10.31	11.14	11.26	11.92	11.44	11.22	11.14	11.16	11.23	11.03	11.11
1873	11.24	11.16	10.98	12.38	12.72	12.51	12.38	12.11	12.01	11.78	11.60	11.95	11.90
1874	12.42	12.95	13.14	12.75	12.97	12.69	12.53	12.41	11.98	11.78	11.55	11.47	12.39
1875	11.77	10.52	11.03	11.67	11.98	11.80	11.82	11.58	11.50	11.29	11.24	11.19	11.45
1876	11.63	11.80	11.49	13.00	13.47	13.31	13.28	12.93	12.53	12.51	12.08	12.43	12.54
1877	12.31	11.78	11.75	12.29	12.15	11.95	12.00	11.89	11.58	11.13	11.35	11.33	11.79
1878	11.83	11.53	12.13	12.33	12.41	12.24	12.23	12.28	12.23	12.21	12.14	12.75	12.19
1879	12.98	13.18	12.22	12.18	12.57	12.21	12.12	11.87	11.61	11.39	11.11	11.37	12.06
1880	11.70	11.86	11.97	12.27	12.16	12.15	12.06	11.73	11.33	11.22	11.48	11.38	11.78
1881	10.98	10.73	11.48	11.70	11.81	11.88	11.93	11.73	11.38	11.26	11.33	11.35	11.46
1882	11.53	11.53	12.31	12.44	12.46	12.75	12.67	12.52	12.23	11.81	11.45	11.50	12.10
1883	11.23	11.07	11.17	12.29	12.51	12.84	12.91	12.72	12.57	12.19	12.33	12.28	12.18
1884	12.11	12.13	12.58	13.22	13.23	12.88	12.82	12.41	12.44	12.11	11.86	11.98	12.48
1885	12.22	12.46	10.03	11.37	12.42	12.67	12.63	12.36	12.23	12.23	12.54	12.88	12.17
1886	13.33	13.08	12.34	13.46	13.18	13.10	12.82	12.57	12.15	12.20	12.12	12.38	12.73
1887	12.28	12.53	12.40	13.26	13.24	12.88	12.54	12.06	11.94	11.63	11.29	11.27	12.27
1888	12.53	10.59	11.07	12.09	12.07	11.97	11.81	11.69	11.60	11.43	11.56	12.11	11.71
1889	12.05	11.88	11.54	12.22	12.13	12.37	11.90	12.34	11.85	11.67	11.49	12.03	11.96
1890	12.95	12.42	12.57	12.92	13.43	13.27	13.13	12.71	12.69	12.37	12.52	12.66	12.80
1891	12.44	12.48	12.83	13.19	13.03	12.49	12.43	12.17	11.87	11.44	11.22	11.27	12.24
1892	11.22	10.74	10.83	11.83	11.65	12.03	12.53	12.38	12.15	11.70	11.70	11.64	11.70
1893	11.38	10.53	11.11	12.26	13.00	12.83	12.68	12.15	12.36	11.95	11.76	11.96	12.00
1894	11.78	11.17	12.06	12.08	12.31	12.47	12.13	11.67	11.54	11.47	11.45	11.10	11.77
1895	11.50	10.57	10.68	11.95	11.46	11.28	10.96	10.98	10.54	10.39	10.17	10.47	10.91
Mean (36 years)	12.11	11.81	11.84	12.47	12.63	12.59	12.47	12.25	12.04	11.84	11.77	11.89	12.14
Mean (25 years) 1871–1895	11.95	11.65	11.69	12.35	12.49	12.44	12.33	12.10	11.89	11.67	11.60	11.73	11.99

TABLE NO. 12.—*St. Lawrence River at Montreal, Province of Quebec.*

[Monthly mean of water levels above the lower miter sill of old lower lock of the Lachine Canal. Elevation of miter sill is 7.10 feet above mean tide at New York City.]

Year.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Mean
	Feet.	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*
1860	32.75	28.83	28.75	22.83	23.08	20.50	19.42	18.83	18.50	18.75	19.50	24.00	22.98
1861	33.17	30.58	30.92	30.50	26.25	23.67	21.58	20.08	19.08	19.08	20.67	21.00	24.72
1862	33.58	31.58	31.08	30.17	24.83	21.50	19.75	19.25	19.42	19.08	19.42	21.58	24.27
1863	28.50	30.00	28.42	30.17	23.58	21.25	19.75	18.83	18.25	18.25	19.08	22.08	23.18
1864	33.42	31.00	29.58	25.50	25.42	21.42	19.25	18.33	18.00	18.83	19.67	22.17	23.55
1865	32.92	31.17	31.17	27.33	24.08	21.08	20.33	19.17	17.75	17.00	16.75	19.83	23.22
1866	29.25	26.92	27.00	26.75	21.83	21.67	19.75	18.83	19.50	18.83	20.08	22.17	22.72
1867	33.92	32.33	31.17	30.08	25.00	23.83	20.83	19.00	18.00	17.58	16.75	25.58	24.51
1868	27.67	25.17	27.17	24.17	20.92	20.00	17.92	17.17	16.92	16.42	17.08	23.83	21.20
1869	28.58	26.17	25.58	29.92	25.25	21.83	20.42	19.75	20.00	20.25	18.50	25.67	23.49
1870	33.08	32.17	29.83	30.25	24.42	20.67	19.33	18.75	18.08	17.67	18.50	18.75	23.46
1871	31.33	29.17	30.17	23.33	23.42	20.50	18.92	17.83	17.00	16.50	16.42	27.50	22.67
1872	27.25	25.33	25.75	27.75	21.17	20.17	17.67	16.75	16.83	17.58	17.17	19.75	21.10
1873	25.92	24.75	25.25	31.42	24.17	22.25	19.67	18.33	17.25	18.17	18.50	25.75	22.63
1874	33.58	31.00	30.50	28.25	22.17	23.25	20.58	18.42	17.25	16.83	16.42	21.50	23.31
1875	27.83	24.25	25.75	28.25	22.75	20.17	18.08	17.50	16.83	16.92	16.75	28.83	21.99
1876	28.00	26.83	28.58	30.83	27.42	24.33	21.25	18.83	18.08	17.83	18.17	26.17	23.86
1877	30.33	28.92	28.33	26.08	19.92	18.50	18.08	17.50	16.67	16.50	16.92	17.58	21.28
1878	26.92	30.83	26.58	19.75	20.50	19.08	18.25	18.33	17.83	18.33	19.50	20.50	21.37
1879	23.92	30.50	28.83	28.50	24.00	20.75	18.75	17.67	17.00	16.50	16.08	20.92	21.95
1880	30.33	27.92	27.08	25.83	23.08	21.42	18.92	17.58	16.83	16.67	18.08	22.50	22.19
1881	27.25	25.08	26.33	23.50	21.33	19.25	17.75	17.00	16.17	15.75	16.08	16.25	20.15
1882	25.83	29.92	28.67	22.17	21.83	22.58	20.75	19.08	18.50	17.50	17.25	22.50	22.22
1883	26.33	25.00	25.75	28.42	21.58	22.17	21.42	19.50	18.17	17.92	18.42	23.08	22.31
1884	34.17	31.42	31.08	30.75	24.08	20.92	19.25	18.75	17.67	17.58	17.92	22.08	23.81
1885	31.58	28.00	26.50	30.92	24.50	21.75	20.67	18.83	18.08	19.33	18.08	21.75	23.33
1886	34.42	31.75	29.33	31.67	23.42	21.08	19.83	18.83	18.00	18.00	18.08	25.58	24.17
1887	30.08	28.83	29.50	33.08	25.58	21.08	19.25	18.08	16.08	16.58	16.17	18.00	22.69
1888	29.67	25.67	26.58	29.50	22.92	21.83	19.00	17.50	17.17	16.75	18.00	20.33	22.08
1889	28.33	29.33	27.67	24.67	21.17	22.08	20.08	18.50	17.08	16.83	16.33	17.58	21.64
1890	29.67	32.92	31.42	26.42	23.58	23.75	20.83	19.00	19.00	18.00	17.92	26.58	24.09
1891	28.67	27.17	29.33	28.25	22.92	19.50	18.25	18.00	17.00	15.92	15.67	17.50	21.52
1892	24.17	28.50	25.75	23.33	18.58	19.42	19.33	18.25	17.08	16.58	17.08	20.17	20.69
1893	29.58	25.92	26.33	27.42	23.75	22.50	19.58	18.08	17.83	16.83	16.50	26.25	22.55
1894	30.83	26.92	29.00	23.83	22.00	20.50	19.17	17.00	16.17	16.58	16.83	17.33	21.34
1895	28.92	24.67	23.08	25.33	20.50	18.58	15.83	15.33	14.50	13.83	13.83	21.08	19.62
Mean (36 years)	29.77	28.51	28.16	27.42	23.08	21.24	19.43	18.29	17.60	17.43	17.62	22.05	22.55
Mean (25 years, 1871–1895)	29.00	28.02	27.73	27.17	22.65	21.10	19.25	18.02	17.20	17.03	17.13	21.88	22.18

TABLE NO. 13.—*Lake Champlain at Fort Montgomery, N. Y.*

[Monthly mean of water levels above the zero of the United States Engineer gauge, the elevation of which zero is 94.53 feet above mean tide at New York City.]

Year.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Mean
	Feet.	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*
1871	(2.02)	(2.13)	3.95	4.45	4.28	2.70	1.80	1.56	1.94	1.45	1.50	(1.91)	2.47
1872	(1.96)	(2.06)	(2.56)	(4.01)	4.32	3.94	2.97	3.03	4.60	3.80	3.90	3.46	3.43
1873	(3.21)	(2.99)	2.76	5.99	6.49	4.15	2.50	1.81	1.03	1.38	2.17	(3.15)	3.14
1874	4.15	(4.19)	(4.40)	(5.00)	5.13	5.06	3.88	3.34	2.10	1.64	1.06	.89	3.41
1875	.72	.74	1.59	4.38	4.91	3.57	2.44	1.80	1.42	1.74	2.59	2.31	2.35
1876	3.18	3.06	3.61	5.16	6.61	4.73	3.06	1.78	.97	.77	.68	.48	2.84
1877	.46	.54	1.47	4.36	3.89	2.43	2.22	2.00	1.56	1.39	2.22	2.60	2.10
1878	2.06	1.56	2.54	4.42	4.84	3.02	1.99	2.82	2.71	1.55	1.75	4.05	2.78
1879	3.32	2.70	3.01	4.44	6.00	3.73	2.50	1.64	1.02	.66	.81	2.24	2.67
1880	2.33	3.06	3.56	3.88	3.54	2.33	1.51	.87	.31	.15	1.70	1.47	2.06
1881	1.04	1.44	3.06	3.46	4.63	3.21	1.99	1.38	.94	.02	1.06	1.54	2.03
1882	2.56	2.37	3.80	3.50	3.26	3.89	3.01	1.86	1.25	1.13	.63	.30	2.30
1883	.20	.50	1.02	4.05	4.98	4.02	2.93	1.80	.86	.40	.40	.46	1.80
1884	.58	1.58	3.30	5.68	5.30	3.63	2.05	1.63	.63	.48	.70	1.45	2.25
1885	2.36	2.29	1.94	4.48	5.60	3.40	2.41	1.85	1.88	1.96	3.79	3.76	2.98
1886	3.84	3.58	3.43	5.20	4.39	3.06	2.05	1.39	.83	.84	1.48	2.82	2.74
1887	2.14	3.34	2.81	5.36	6.37	4.45	2.91	1.94	1.19	.58	.47	1.87	2.79
1888	2.12	2.20	2.77	5.40	6.57	4.51	2.77	1.72	1.93	2.43	3.38	3.65	3.29
1889	4.41	3.64	3.13	4.62	4.47	3.98	3.41	2.76	1.85	2.36	2.52	3.32	3.37
1890	3.04	3.58	4.30	4.76	5.72	5.27	3.07	1.86	3.13	3.01	3.12	2.88	3.65
1891	2.71	3.58	5.30	6.31	5.23	3.13	1.94	1.43	1.16	.61	.50	1.13	2.75
1892	2.90	2.70	2.32	4.57	3.92	4.37	5.41	4.27	3.42	2.06	2.25	2.23	3.37
1893	1.50	1.33	1.87	3.65	4.96	3.53	1.89	1.37	2.46	1.54	.96	.99	2.17
1894	1.93	1.99	3.64	3.93	3.30	2.72	1.88	1.03	.59	.56	1.06	1.11	1.98
1895	1.31	1.20	1.23	4.01	4.86	3.13	1.76	1.26	1.13	.60	1.00	2.67	2.01
Mean (21 years, 1875–1895)	2.13	2.24	2.84	4.53	4.92	3.62	2.53	1.83	1.49	1.21	1.58	2.06	2.58
Mean (25 years, 1871–1895)	2.24	2.33	2.93	4.60	4.94	3.63	2.57	1.95	1.64	1.35	1.67	2.11	2.67

NOTE.—Interpolated monthly means are indicated by parentheses, and are found as follows: For January and February, 1871, by taking the corresponding means of the monthly means in the twenty-one year series, 1875 to 1895, and correcting them by the average difference between the observed monthly means for 1871 and the corresponding means in the twenty-one year series; for December, 1871, and January, February, March, and April, 1872, by proportioning the difference between November, 1871, and May, 1872, according to the difference between the corresponding months in the twenty-one year series, and in the same manner for February, March, and April, 1874; for January, February, and December, 1873, by direct interpolation.

TABLE NO. 13*a*.—*River Richelieu at Lock No. 1 of the Chambly Canal at St. Johns Province of Quebec.*

[Depth of water on the upper miter sill of Lock No. 1. The elevation of the upper miter sill is 87.41 feet above mean tide at New York City.]

Year.	Stage.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
		Feet.	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*
1863	Highest	.....	.....	.....	.....	.....	.....	.....	.....	.....	9.83	9.33	.....
	Lowest	.....	.....	.....	.....	.....	.....	.....	.....	.....	8.42	8.42	.....
1864	Highest	.....	.....	.....	.....	11.33	10.92	8.75	7.92	8.00	8.67	9.75	10.00
	Lowest	.....	.....	.....	.....	10.67	8.58	7.83	7.42	7.17	7.83	8.58	9.75
1865	Highest	.....	.....	.....	.....	11.50	10.67	9.33	8.92	8.00	8.25	7.25	.....
	Lowest	.....	.....	.....	11.67	10.67	9.25	8.67	7.83	7.25	6.75	6.50	.....
1866	Highest	.....	.....	.....	.....	10.50	10.00	9.25	8.67	9.75	9.42	9.83	.....
	Lowest	.....	.....	.....	10.50	9.67	9.17	8.42	8.08	8.25	9.00	8.83	9.92
1867	Highest	.....	.....	.....	.....	12.75	12.33	.....	.....	.....	.....	.....	.....
	Lowest	.....	.....	.....	.....	11.50	10.50	.....	.....	.....	.....	.....	.....
1868	Highest	.....	.....	.....	10.25	10.79	10.92	9.33	8.58	8.25	9.67	9.75	9.42
	Lowest	.....	.....	.....	9.58	9.00	9.25	8.25	7.58	7.08	7.17	7.33	8.75
1869	Highest	9.33	9.00	9.25	13.87	13.83	12.17	10.25	9.33	8.58	11.42	11.08	10.25
	Lowest	8.67	8.83	8.75	9.33	12.25	10.17	9.08	8.33	8.25	8.17	9.83	9.17
1870	Highest	10.25	10.33	10.00	12.67	12.33	10.25	9.08	8.25	8.08	9.50	9.00	8.08
	Lowest	9.42	9.58	9.17	10.17	10.17	8.75	8.17	7.33	7.17	7.00	7.50	7.75

NOTE.—The slope or fall during extreme high water (April, 1869), from Lake Champlain, at Fort Montgomery, to St. Johns, was about 2 feet when the depth of water on miter sill of Lock No. 1 was 13.87 feet. The slope or fall, during extreme low water, from Lake Champlain, at Fort Montgomery, to St. Johns, was 0.38 feet when the depth of water on miter sill of Lock No. 1 was 5.88 feet. These are the highest and lowest waters on record, and they, as well as the slopes, are given on the authority of R. Steckel, engineer in charge of the Canadian geodetic leveling.

TABLE NO. 14.—*St. Lawrence River at Montreal, Province of Quebec.*

[Depth of water in feet and decimals in the Montreal Harbor over miter sill of old lower lock of the Lachine Canal, deduced from gaugings taken at noon each day, except that after 1882 the highest point is recorded on the highest day in the spring and fall of each year independent of the time of day it was reached. Elevation of the miter sill is 7.10 feet above mean tide at New York City.]

Year.	January.			February.			March.			April.		
	High.	Low.	Mean.	High.	Low.	Mean.	High.	Low.	Mean.	High.	Low.	Mean.
	Feet.	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*
1850	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
1851	.....	.....	.....	.....	.....	.....	.....	.....	.....	32.33	21.83	.....
1852	33.75	28.75	.....	29.92	16.92	.....	29.92	16.58	.....	32.83	23.50	.....
1853	35.25	25.58	.....	33.25	31.58	.....	32.17	31.25	.....	32.17	22.17	.....
1854	37.75	31.50	.....	32.08	29.25	.....	32.00	29.83	.....	32.00	25.00	.....
1855	31.75	27.58	.....	27.33	25.00	.....	27.33	24.75	.....	34.50	24.58	.....
1856	30.50	27.00	32.42	30.92	29.00	29.25	29.50	26.25	27.50	36.75	21.00	28.25
1857	34.50	29.25	31.33	31.25	28.75	30.08	30.58	28.67	29.33	32.50	21.00	27.58
1858	38.25	24.00	32.42	33.17	30.00	31.58	32.00	29.50	30.75	36.50	22.17	25.42
1859	36.42	30.50	32.08	30.83	28.00	29.42	36.42	28.00	30.58	29.58	21.75	23.93
1860	34.25	30.17	32.75	29.92	27.17	28.83	29.50	28.17	28.75	28.58	20.50	22.83
1861	36.33	31.33	33.17	31.42	28.75	30.58	32.33	29.83	30.92	41.58	24.25	30.50
1862	36.50	27.42	33.58	32.67	30.08	31.58	31.67	30.50	31.08	35.42	25.17	30.17
1863	33.17	23.08	28.50	31.83	28.33	30.00	29.25	27.58	28.42	36.75	25.25	30.17
1864	37.50	32.00	33.42	32.58	29.75	31.00	30.25	28.67	29.58	32.50	21.42	25.50
1865	36.83	24.42	32.92	32.58	29.50	31.17	33.42	29.00	31.17	40.75	22.75	27.33
1866	32.42	27.67	29.25	28.67	25.75	26.92	27.75	26.42	27.00	33.17	22.67	26.75
1867	37.67	29.25	33.92	33.00	31.58	32.33	31.83	30.42	31.17	33.00	24.00	30.08
1868	29.25	25.50	27.67	25.92	24.08	25.17	29.42	24.92	27.17	32.83	19.00	24.17
1869	31.00	26.83	28.58	27.42	25.25	26.17	26.83	24.50	25.58	40.42	24.75	29.92
1870	36.50	25.08	33.08	33.75	31.25	32.17	32.33	28.00	29.83	36.83	26.25	30.25
1871	34.75	26.75	31.33	31.08	28.00	29.17	32.00	28.42	30.17	32.00	21.00	23.33
1872	29.00	26.00	27.25	26.42	24.33	25.33	26.75	24.42	25.75	30.50	21.25	27.75
1873	27.42	24.58	25.92	25.67	24.08	24.75	26.17	24.50	25.25	38.67	26.42	31.42
1874	34.67	32.33	33.58	32.17	29.67	31.00	31.58	28.75	30.50	33.00	22.00	28.25
1875	30.00	25.75	27.83	27.92	23.00	24.25	26.75	23.83	25.75	30.75	24.42	28.25
1876	30.00	26.42	28.00	27.75	25.83	26.83	29.58	27.17	28.58	34.17	26.92	30.83
1877	32.33	28.42	30.33	30.83	27.42	28.92	29.75	27.25	28.33	31.33	21.00	26.08
1878	34.25	17.08	26.92	33.50	29.25	30.83	29.67	20.33	26.58	20.42	18.83	19.75
1879	33.83	19.42	23.92	33.17	28.25	30.50	30.00	28.25	28.83	34.25	22.42	28.50
1880	32.33	28.33	30.33	29.83	26.67	27.92	28.50	25.75	27.08	33.58	22.25	25.83
1881	30.75	24.25	27.25	25.83	24.00	25.08	28.50	24.75	26.33	30.17	17.83	23.50
1882	33.83	16.75	25.83	32.50	28.08	29.92	31.25	27.08	28.67	31.00	19.33	22.17
1883	28.50	24.25	26.33	26.25	24.25	25.00	26.75	24.58	25.75	33.42	22.25	28.42
1884	38.45	30.58	34.17	33.25	30.58	31.42	34.58	29.25	31.08	38.50	22.42	30.75
1885	35.25	28.83	31.58	29.92	26.67	28.00	28.08	25.00	26.50	40.67	26.17	30.92
1886	39.50	28.00	34.42	33.75	28.67	31.75	30.25	28.33	29.33	44.33	25.42	31.67
1887	32.42	28.42	30.08	30.25	27.08	28.83	30.25	28.83	29.50	43.12	27.58	33.08
1888	33.67	26.25	29.67	28.08	24.00	25.67	28.50	24.75	26.58	36.50	22.17	29.50
1889	35.50	23.92	28.33	31.50	26.58	29.33	29.00	26.67	27.67	34.08	19.83	24.67
1890	36.75	18.83	29.67	34.75	31.33	32.92	32.92	29.75	31.42	35.08	21.67	26.42
1891	30.50	26.92	28.67	29.17	25.92	27.17	31.67	27.75	29.33	33.92	24.08	28.25
1892	32.67	16.92	24.17	31.92	24.50	28.50	26.92	24.50	25.75	36.50	17.00	23.33
1893	32.75	26.58	29.58	27.58	25.08	25.92	27.83	25.00	26.33	33.08	22.08	27.42
1894	33.08	28.92	30.83	28.75	25.08	26.92	30.33	25.92	29.00	31.50	20.25	23.83
1895	32.33	27.00	28.92	27.42	23.08	24.67	24.50	22.00	23.08	34.67	20.83	25.33

TABLE No. 14.—*St. Lawrence River at Montreal, Province of Quebec*—Continued.

Year.	May.			June.			July.			August.		
	High.	Low.	Mean.	High.	Low.	Mean.	High.	Low.	Mean.	High.	Low.	Mean.
	Feet.	Feet.	Feet.	Feet.	Feet.	Feet.	Feet.	Feet.	Feet.	Feet.	Feet.	Feet.
1850	26.25	21.75	.....	23.75	19.00	.....	19.75	18.25	.....	18.83	17.00	.....
1851	24.75	22.33	.....	23.83	21.17	.....	21.17	19.50	.....	19.92	17.83	.....
1852	25.75	23.00	.....	22.75	21.42	.....	22.00	19.33	.....	20.00	18.08	.....
1853	25.00	22.58	.....	24.00	21.25	.....	21.25	19.00	.....	19.00	18.58	.....
1854	27.00	23.17	.....	23.67	20.58	.....	20.67	18.83	.....	18.83	17.42	.....
1855	24.58	22.33	.....	23.00	21.00	.....	21.17	18.92	.....	19.08	18.00	.....
1856	22.00	20.17	21.08	20.00	19.08	19.42	19.25	18.83	19.08	19.00	18.00	18.33
1857	25.42	20.42	23.83	23.83	23.00	23.50	22.75	21.00	21.58	21.42	20.50	21.58
1858	23.58	22.33	23.00	23.83	21.75	22.58	22.42	20.58	21.42	20.92	19.58	20.33
1859	24.50	22.17	23.67	23.75	21.92	23.67	22.00	20.33	21.00	20.33	19.25	19.83
1860	23.75	20.58	23.08	22.42	20.33	20.50	20.33	18.67	19.42	19.25	18.58	18.83
1861	27.17	25.42	26.25	26.75	21.58	23.67	22.25	20.58	21.58	20.67	19.33	20.08
1862	26.33	23.00	24.83	22.83	20.33	21.50	20.33	19.33	19.75	19.75	18.75	19.25
1863	24.83	22.00	23.58	22.83	20.08	21.25	20.17	19.25	19.75	19.50	18.33	18.83
1864	26.33	24.00	25.42	23.92	19.83	21.42	20.00	18.50	19.25	18.58	18.00	18.33
1865	24.58	23.25	24.08	23.25	19.92	21.08	20.42	19.83	20.33	19.75	18.33	19.17
1866	23.75	21.25	21.83	22.83	21.00	21.67	20.75	19.00	19.75	19.25	18.42	18.83
1867	26.42	24.58	25.00	25.50	21.83	23.83	21.83	19.67	20.83	19.75	18.42	19.00
1868	23.00	19.08	20.92	21.83	18.67	20.00	18.67	17.50	17.92	17.67	16.67	17.17
1869	26.83	23.92	25.25	23.50	21.17	21.83	21.50	19.83	20.42	20.17	19.33	19.75
1870	26.83	21.58	24.42	21.83	19.83	20.67	19.67	19.08	19.33	19.17	18.25	18.75
1871	24.50	22.00	23.42	22.17	19.58	20.50	19.50	18.42	18.92	18.50	17.08	17.83
1872	21.23	20.00	21.17	21.08	18.33	20.17	18.42	17.17	17.67	17.08	16.00	16.75
1873	25.25	22.75	24.17	25.08	20.50	22.25	20.50	18.83	19.67	18.83	17.42	18.33
1874	24.50	20.17	22.17	24.42	22.00	23.25	22.17	19.33	20.58	19.58	17.42	18.42
1875	24.83	20.25	22.75	22.92	17.75	20.17	18.83	17.75	18.08	17.92	17.25	17.50
1876	28.67	25.42	27.42	26.83	22.75	24.33	22.42	19.75	21.25	19.67	18.25	18.83
1877	21.25	19.25	19.92	19.25	18.17	18.50	18.33	17.92	18.08	17.92	17.17	17.50
1878	21.25	19.75	20.50	19.67	18.58	19.08	18.75	18.00	18.25	18.67	18.00	18.33
1879	25.58	22.50	24.00	22.42	19.58	20.75	19.67	18.50	18.75	18.50	17.17	17.67
1880	23.83	22.00	23.08	22.67	19.92	21.42	19.92	18.33	18.92	18.33	16.83	17.58
1881	22.58	19.17	21.33	21.25	18.17	19.25	18.17	17.42	17.75	17.42	16.25	17.00
1882	22.83	20.17	21.83	23.50	21.67	22.58	21.75	19.50	20.75	19.67	18.83	19.08
1883	22.67	20.83	21.58	23.08	21.67	22.17	22.50	20.50	21.42	20.58	18.58	19.50
1884	24.42	22.83	24.08	22.58	19.75	20.92	19.58	18.75	19.25	19.33	18.08	18.75
1885	34.08	22.83	24.50	23.17	20.83	21.75	21.42	19.67	20.67	19.75	18.08	18.83
1886	25.08	21.92	23.42	21.67	20.50	21.08	20.58	19.33	19.83	19.50	18.08	18.83
1887	27.00	22.75	25.58	22.58	19.67	21.08	19.58	18.67	19.25	18.58	17.33	18.08
1888	24.67	20.83	22.92	23.00	20.92	21.83	20.50	17.83	19.00	17.92	17.25	17.50
1889	23.08	19.58	21.17	22.50	19.75	22.08	21.17	19.17	20.08	19.58	17.67	18.50
1890	24.58	22.08	23.58	24.25	22.33	23.75	22.17	19.42	20.83	19.58	18.58	19.00
1891	24.25	21.00	22.92	21.00	18.58	19.50	18.58	17.92	18.25	18.42	17.33	18.00
1892	19.33	17.92	18.58	20.92	18.50	19.42	21.25	17.92	19.33	19.50	17.42	18.25
1893	25.42	20.75	23.75	24.00	20.75	22.50	20.58	18.75	19.58	20.25	17.17	18.08
1894	23.25	20.75	22.00	21.50	19.83	20.50	20.17	17.75	19.17	17.92	16.25	17.00
1895	21.58	19.25	20.50	19.50	17.42	18.58	17.25	15.17	15.83	15.67	15.00	15.33

TABLE NO. 14.—*St. Lawrence River at Montreal, Province of Quebec*—Continued.

Year.	September.			October.			November.			December.		
	High.	Low.	Mean.	High.	Low.	Mean.	High.	Low.	Mean.	High.	Low.	Mean.
	Feet.	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*
1850	17.50	17.00	.....	18.33	17.00	.....	18.33	17.00	.....	33.00	17.58	.....
1851	17.58	17.00	.....	17.58	16.92	.....	17.67	16.92	.....	33.33	17.00	.....
1852	18.58	18.00	.....	19.00	18.17	.....	19.83	18.42	.....	24.25	19.25	.....
1853	19.33	18.08	.....	19.42	18.58	.....	20.00	18.75	.....	30.67	18.33	.....
1854	17.67	17.08	.....	17.50	17.08	.....	18.25	17.08	.....	30.25	17.92	.....
1855	18.17	17.75	.....	19.58	18.00	.....	22.00	18.58	.....	25.58	19.00	.....
1856	18.42	17.75	18.00	18.83	17.58	18.33	17.83	17.00	17.50	34.83	17.08	23.75
1857	20.50	19.50	19.83	20.42	19.17	19.58	21.58	19.58	20.50	23.08	19.83	20.50
1858	21.42	20.00	20.75	21.17	19.33	20.42	20.17	18.75	19.58	33.50	18.17	23.42
1859	19.50	18.83	19.17	19.50	18.58	19.08	22.17	18.25	19.75	35.92	20.25	26.33
1860	19.58	18.00	18.50	19.00	18.42	18.75	20.00	18.83	19.50	32.58	18.75	24.00
1861	19.75	18.75	19.08	20.83	19.83	19.08	21.25	20.00	20.67	26.42	19.83	21.00
1862	20.17	18.67	19.42	19.67	18.75	19.08	20.17	18.83	19.42	28.17	18.67	21.58
1863	18.50	18.00	18.25	18.50	17.83	18.25	20.17	18.00	19.08	32.00	18.75	22.08
1864	18.50	17.58	18.00	19.58	18.08	18.83	20.50	18.83	19.67	25.75	20.33	22.17
1865	18.25	17.25	17.75	17.33	16.33	17.00	17.50	16.25	16.75	28.17	16.67	19.83
1866	20.67	18.58	19.50	20.17	17.83	18.83	22.17	18.50	20.08	25.50	21.42	22.17
1867	18.50	17.58	18.00	17.83	17.25	17.58	17.08	16.42	16.75	32.75	16.58	25.58
1868	17.17	16.58	16.92	16.92	16.00	16.42	17.83	16.33	17.08	31.83	16.67	23.83
1869	20.92	19.00	20.00	21.50	19.25	20.25	19.00	18.00	18.50	32.17	18.50	25.67
1870	18.58	17.58	18.08	18.33	17.17	17.67	18.92	18.17	18.50	25.25	17.67	18.75
1871	17.75	16.42	17.00	16.92	16.17	16.50	16.83	16.08	16.42	31.42	16.17	27.50
1872	17.33	16.50	16.83	18.17	16.58	17.58	17.83	16.33	17.17	27.25	16.17	19.75
1873	17.50	17.00	17.25	19.08	17.25	18.17	19.50	17.83	18.50	34.58	20.25	25.75
1874	17.50	17.00	17.25	17.08	16.42	16.83	16.58	16.17	16.42	29.58	16.17	21.50
1875	17.25	16.50	16.83	17.50	16.50	16.92	17.58	16.17	16.75	32.83	19.17	28.83
1876	18.25	17.75	18.08	18.17	17.58	17.83	18.33	17.67	18.17	34.92	17.75	26.17
1877	17.25	16.42	16.67	16.92	16.17	16.50	17.83	16.42	16.92	17.92	17.08	17.58
1878	18.25	17.58	17.83	20.00	17.75	18.33	20.25	18.92	19.50	21.83	19.42	20.50
1879	17.17	16.67	17.00	16.92	15.83	16.50	17.00	15.42	16.08	32.25	16.08	20.92
1880	17.08	16.33	16.83	17.17	16.25	16.67	19.08	16.50	18.08	31.42	17.58	22.50
1881	16.50	15.67	16.17	15.92	15.42	15.75	16.33	15.58	16.08	16.50	16.00	16.25
1882	19.00	18.00	18.50	18.67	17.08	17.50	17.67	16.75	17.25	30.17	16.50	22.50
1883	18.58	17.02	18.17	18.33	17.00	17.92	19.25	18.08	18.42	35.83	18.75	23.08
1884	18.08	17.42	17.67	18.00	17.42	17.58	18.75	17.33	17.92	34.17	17.25	22.08
1885	18.25	17.83	18.08	20.00	18.08	19.33	19.17	17.50	18.08	30.75	18.08	21.75
1886	18.25	17.83	18.00	18.25	17.75	18.00	18.75	17.67	18.08	33.50	18.00	25.58
1887	17.50	16.50	16.08	16.92	16.25	16.58	16.50	15.83	16.17	31.00	16.00	18.00
1888	17.50	16.75	17.17	17.25	16.33	16.75	20.08	16.58	18.00	27.00	16.17	20.33
1889	17.58	16.83	17.08	17.42	16.08	16.83	17.17	15.67	16.33	18.67	16.50	17.58
1890	20.08	18.25	19.00	18.42	17.75	18.00	18.75	17.50	17.92	33.92	17.33	26.58
1891	17.67	16.25	17.00	16.33	15.50	15.92	17.50	14.92	15.67	18.50	16.42	17.50
1892	18.08	16.67	17.08	17.08	16.00	16.58	18.25	16.25	17.08	33.00	16.67	20.17
1893	20.33	17.00	17.83	17.17	16.42	16.83	16.92	16.17	16.50	35.50	16.08	26.25
1894	16.42	15.92	16.17	17.08	16.00	16.58	17.33	16.00	16.83	27.17	15.92	17.33
1895	15.00	13.83	14.50	14.33	13.17	13.83	15.50	13.25	13.83	29.50	14.75	21.08

TABLE NO. 15.—*St. Lawrence River from Prescott to Montreal.*

[Monthly mean of water levels above or below the zero of gauge at Ogdensburg and above miter sills of the several locks at the places named.]

Elevations of the several planes of reference, in feet, above mean tide at New York City:

Ogdensburg	245.33	Cornwall, new Lock 15	139.28
Galops, old Lock 27	235.15	Valleyfield, old Lock 14	142.52
Galops, old Lock 25	218.52	Melocheville, old Lock 6	60.83
Rapide Plat, old Lock 23	205.82	Lachine, old Lock 5	58.39
Farrans Point, old Lock 22	193.77	Montreal, old Lock 1	7.10
Cornwall, old Lock 15	144.86		

Month.	Ogdensburg.	Galops Canal.		Rapide Plat, Lock 23.	Farrans Point, Lock 22.	Cornwall, Lock 15.	Valleyfield, Lock 14.	Melocheville, Lock 6.	Lachine, Lock 5.	Montreal, Lock 1.
		Lock 27.	Lock 25.							
1870.	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet. Old Lock.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*
January	1.69	10.75	12.25	10.42	8.04	17.08	12.83	12.75	11.75	33.08
February	1.73	.....	.....	.....	.....	25.42	12.98	14.75	11.50	32.17
March	1.53	10.50	12.25	10.50	7.92	22.83	12.36	14.42	10.92	29.83
April	2.72	11.50	14.25	11.83	9.42	13.25	13.31	14.50	14.75	30.25
May	3.24	12.67	15.67	12.58	10.83	12.42	13.42	14.67	14.92	24.42
June	2.97	12.42	15.33	12.33	10.75	12.08	13.28	13.08	12.58	20.67
July	2.73	12.25	15.17	12.08	10.50	11.92	13.17	12.50	11.92	19.33
August	2.40	11.75	14.08	11.42	10.33	11.67	12.94	11.75	11.42	18.75
September	1.56	10.67	13.58	10.75	9.92	11.17	12.54	10.92	10 83	18.08
October	1.24	10.50	13.00	10.50	9.50	10.92	12.44	10.42	10.67	17.67
November	1.01	10.33	12.25	10.17	9.25	10.58	12.28	.....	11.00	18.50
December	*a* .87	10.08	12.08	10.04	8.75	11.00	12.19	10.92	10.75	18.75
1895.						*New Lock.*				
January	.....	8.00	8.83	6.92	8.33	15.83	11.50	12.75	10.75	28.92
February	.....	7.17	7.50	7.42	7.25	14.17	10.57	15.67	9.08	24.67
March	.....	7.42	8.00	7.92	7.33	14.08	10.68	13.17	8.58	23.08
April	.....	8.50	9.92	7.50	8.33	(15.69)	11.95	12.17	11.75	25.33
May	— .50	8.83	10.33	7.75	8.50	15.25	11.46	12.33	12.33	20.50
June	— .67	8.67	10.17	7.58	8.33	15.08	11.28	11.17	11.33	18.58
July	— .92	8.33	9.67	7.17	8.08	(14.70)	10.96	9.67	9.83	15.83
August	—1.09	8.25	9.42	6.92	7.92	14.67	10.98	9.17	9.50	15.33
September	—1.54	7.92	8.83	6.42	7.50	14.33	10.54	8.67	8.92	14.50
October	*a*—1.75	7.67	8.33	5.92	7.17	14.04	10.39	8.58	8.67	13.83
November	.....	7.42	7.83	5.50	6.67	13.92	10.17	8.33	8.50	13.83
December	.....	7.58	7.83	5.92	7.00	14.33	10.47	9.67	9.67	21.08

a No record for the last seven days of the month.

NOTE.—Interpolated monthly means are indicated by parentheses. The interpolation (April and July, 1895) at Cornwall was made by comparing with the record at Valleyfield and assuming that the slope between the two points was practically the same as for the preceding and following months.

Water levels for 1896 for the Great Lakes and St. Lawrence River.

[Monthly mean of water levels above or below the plane of reference adopted for the several localities and given in the "Tables of Water Levels."]

Date.	Lake Superior at Duluth.	Sault Ste Marie.		Lake Michigan at Milwaukee.	Lake Huron at Sand Beach.	Lake Erie at Cleveland.	Lake Ontario at Oswego.	Lake Champlain at Fort Montgomery.	St. Lawrence River.	
		Above the locks.	Below the locks.						Valleyfield.	Montreal.
1896.	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*
January	3.00	3.27	582.88	5.67	5.69	4.15	−0.32	3.28	11.20	27.63
February	3.20	3.27	582.96	5.63	5.57	4.23	.20	2.46	11.19	26.16
March	3.40	3.47	582.63	5.62	5.67	4.28	.37	4.15	10.69	26.02
April	3.31	3.39	582.19	5.44	5.64	3.83	*a* 1.30	6.63	11.96	29.52
May	2.66	2.77	582.11	5.16	5.24	3.45	*b* 1.31	5.59	11.55	20.51
June	2.28	2.36	582.51	4.84	4.87	3.28	1.22	3.08	11.45	18.09
July	2.22	2.23	582.70	4.90	4.81	3.29	.90	2.04	11.25	16.39
August	2.20	2.21	582.85	4.97	4.77	3.14	.82	1.35	11.09	15.55
September	2.37	2.35	582.71	5.07	4.95	3.41	.34	.91	10.77	14.76
October	2.69	2.77	582.25	5.12	5.15	3.65	.13	.92	10.44	14.78

a Three-tenths foot of this (1.30) was due to effect of backwater at gauge from unusual freshet in river.

b Six-tenths hundred foot due to backwater.

EXHIBIT B 3.

BASIN OF THE GREAT LAKES AND OF THE ST. LAWRENCE AND HUDSON RIVERS.[1]

By J. E. MALONEY.

INTRODUCTION.

I have measured the areas of the several lakes, and the St. Lawrence and Hudson rivers, and their watersheds, also several subordinate basins, and submit herewith tabular statements of the results, and a map which shows the basins as a whole, and the important divisions in relation to the surrounding drainage systems.

DATA.

The results were obtained from the following data: Maps and charts issued by the several departments of the Canadian and United States Governments; maps of the geological and other surveys issued by the different States; maps and reports of canal and water power projects; maps compiled by private publishers; reports of the Chief of Engineers, United States Army, and of the State engineer and surveyor of New York; records of private surveys in New York State.

METHOD OF COMPUTATION.

The method pursued was as follows: The areas were divided into quadrilaterals, formed by 30′ of arc on the meridians and parallels.

The area of each quadrilateral was figured by multiplying the middle distances together; for instance, the area between 39° 00′ and 39° 30′ of latitude and any 30′ of longitude was obtained by multiplying the distance between the meridians at the parallel of 39° 15′ into the distance on the meridian from 39° 00′ to 39° 30′. These areas were figured and results tabulated for each 30′ between the limits of latitude covered by the basins, and the tables then used in computing the areas of the several basins. The middle distances are in statute miles and are taken from the tables in the report of the United States Coast and Geodetic Survey for 1884, Appendix No. 6. Quadrilaterals containing part land and part water, or divided by the different watershed lines, were proportioned by means of a planimeter. The work was checked by running the planimeter over the area as a whole and comparing with results obtained by figuring the separate quadrilaterals. The results have in general compared within 1 per cent. An approximate check on the gross area was taken by means of the maps of the United States Geological Survey, and showed a difference of about 1½ per cent in a total of 420,000 square miles.

[1] Accompanied by Map No. B.

AREAS OF WATER.

In the lakes the terminals were placed so as to include as near as possible for each lake all waters on the same level. St. Marys River is divided at the Sault Ste. Marie lock, part going in with Lake Superior and part with Lake Huron. Between Lake Huron and the St. Clair River the division is made at Port Huron just below the mouth of the Black River. Between Lakes Erie and Ontario Niagara Falls is taken as the dividing point. Lake Ontario is considered as ending at the head of Galops Rapids, including part of the St. Lawrence River in its area. The areas of the Great Lakes and of the St. Lawrence River were figured from the charts of the Lake Survey and of the Hydrographic Office of the United States. The areas of the Hudson River, Lake Champlain, and New York Bay were figured from the charts of the Coast and Geodetic Survey. The areas of the Great Lakes and of the St. Lawrence and Hudson rivers and Lake Champlain are as follows:

Name.	Area in square miles.
Lake Superior	31,800
Lake Michigan	22,400
Lake Huron	23,200
Lake St. Clair (including St. Clair and Detroit rivers)	495
Lake Erie	10,000
Lake Ontario	7,450
St. Lawrence River (Galops to mouth)	5,395
Hudson River (Troy to mouth)	140
Lake Champlain	400
Total area of water	101,280

AREAS OF WATERSHEDS.

The lines marking the limits of the watersheds under consideration were carefully determined and marked on the maps of the several basins; the land-office and post-route maps being used for the United States, and the map issued by the department of railways and canals, for Canada. These maps were then checked by means of all the local maps and other data available. This method was followed for all the divisions in the United States and for the subsidiary basins in Canada. The main divisions in Canada were determined and marked on the maps by Dr. G. M. Dawson, deputy head and director of the geological survey, and Mr. Hugh V. Payne, chief of the meteorological office, Canada. The areas of a few of the subsidiary watersheds were taken from actual surveys and are so noted in the tables. The areas of the several main watersheds are as follows:

Name.	Area in square miles.
Lake Superior	48,600
Lake Michigan	45,700
Lake Huron	52,100
Lake St. Clair	6,320
Lake Erie	24,480
Lake Ontario	25,530
St. Lawrence River (exclusive of Ottawa basin and Champlain watershed)	129,385
Hudson River	13,140
Ottawa River (total basin)	56,470
Lake Champlain	7,960
Total area of watersheds	409,685

AREA OF BASINS.

The area of the basin is made up of the area of the water surface and of the watershed, and the areas of the main basins are given in the summary and also in detail in Tables 4 to 13.

ELEVATIONS.

The elevations given in the tables and on the map were reduced in the office of the Commission, and are from the best obtainable data. The elevations of the Great Lakes and of many points on the rivers and divides are given in the tables, and also on the general map. All elevations are in feet above mean tide at New York City.

GENERAL SUMMARY.

The following is a general summary of the several areas which appear in detail in the tables:

Name.	Area of water in square miles.	Area of watershed in square miles.	Area of basin in square miles.
Lake Superior	31,800	48,600	80,400
Lake Michigan	22,400	45,700	68,100
Lake Huron	23,200	52,100	75,300
Lake St. Clair	495	6,320	6,815
Lake Erie	10,000	24,480	34,480
Lake Ontario	7,450	25,530	32,980
St. Lawrence River (Galops to Montreal)	220	5,710	5,930
Total to Montreal	95,565	208,440	304,005
Ottawa River (head to mouth)	.....	.....	*a* 56,470
Lake Champlain	400	7,960	8,360
St. Lawrence River (Montreal to Quebec)	375	37,475	37,850
St. Lawrence River (Quebec to mouth)	4,800	86,200	91,000
Total, Montreal to mouth St. Lawrence River	5,575	131,635	193,680

RECAPITULATION.

Lakes and St. Lawrence River to Montreal	95,565	208,440	304,005
From Montreal to mouth St. Lawrence River	5,575	131,635	193,680
Total to mouth St. Lawrence River	101,140	340,075	497,685
Hudson River	*b* 140	13,140	13,280

a Total basin; water surface and watershed not separated.
b Water area from Troy to mouth only.

TABLES APPENDED.

No. 1 gives the elements used in figuring the areas of the quadrilaterals.

No. 2 is a list of the charts, maps, and other data consulted.

No. 3 shows a comparison of the results with those determined by Mr. L. Y. Schermerhorn, assistant engineer, United States Army, and published in American Journal of Science in 1887. The difference in Lake Huron basin is probably due to the placing of the divide through the Province of Ontario, as the area of the watershed in Ontario, as we figure it, is larger than the total watershed for the lake as Mr. Schermerhorn gives it. Different terminals may account for some of the other differences.

Tables Nos. 4 to 13 show the water and land areas, with elevations, and the areas of the different subdivisions.

Respectfully submitted.

J. E. MALONEY.

Mr. L. E. COOLEY, C. E.,
Engineer, Deep Waterways Commission.

NO. 1.—*Table of distances on meridians and parallels for 30′ of arc, and areas of quadrilaterals formed by 30′ arcs.*

[Areas figured by middle distances.]

Latitude.	Length of 30′ of arc of the meridian in statute miles.	Latitude.	Length of 30′ of arc of the parallels in statute miles.	Latitude.	Area of 30′ quadrilateral in square miles.
° ′		° ′		° ′	
39 00	.....	39 15	26.819	39 00	.....
39 30	34.492	39 45	26.628	39 30	925.1
40 00	34.495	40 15	26.435	40 00	918.5
40 30	34.498	40 45	26.230	40 30	911.9
41 00	34.501	41 15	26.041	41 00	905.3
41 30	34.504	41 45	25.842	41 30	898.5
42 00	34.508	42 15	25.639	42 00	891.8
42 30	34.511	42 45	25.437	42 30	884.8
43 00	34.514	43 15	25.231	43 00	877.9
43 30	34.517	43 45	25.023	43 30	870.9
44 00	34.520	44 15	24.814	44 00	863.8
44 30	34.523	44 45	24.604	44 30	856.7
45 00	34.525	45 15	24.390	45 00	849.3
45 30	34.528	45 45	24.175	45 30	842.1
46 00	34.531	46 15	23.959	46 00	834.8
46 30	34.534	46 45	23.740	46 30	827.4
47 00	34.538	47 15	23.520	47 00	819.9
47 30	34.541	47 45	23.298	47 30	812.4
48 00	34.544	48 15	23.074	48 00	804.8
48 30	34.547	48 45	22.847	48 30	797.1
49 00	34.550	49 15	22.620	49 00	789.4
49 30	34.553	49 45	22.391	49 30	781.6
50 00	34.556	50 15	22.160	50 00	773.7
50 30	34.559	50 45	21.927	50 30	765.8
51 00	34.562	51 15	21.693	51 00	757.8

REMARKS.—Distances on meridians and parallels taken from report of Coast and Geodetic Survey, 1884, Appendix No. 6.

NO. 2—*Table of maps, charts, and other data consulted.*

CANADIAN DATA.

Maps:
- Department of railways and canals.
- Geological survey.
- Crown land department in the Provinces of Quebec and Ontario.
- Lake Simcoe, showing watersheds.
- Report and map of the Georgian Bay route.

Letters:
- Dr. G. M. Dawson, deputy head and director of the geological survey.
- Mr. Hugh V. Payne, chief of meteorological office.

UNITED STATES DATA.

Maps:
- Land Office, Department of Interior.
- Postal route, Post-Office Department.
- Geological survey of Wisconsin and Michigan.
- United States Geological Surveys.
- New York State surveys (geological and Adirondack).
- New Jersey geological survey.
- Sanitary district of Chicago (watersheds in Illinois, Wisconsin, and Indiana).

Charts:
- United States Lake Survey. Charts of the Great Lakes and the St. Lawrence River.
- Hydrographic Office, United States Navy.
- United States Coast and Geodetic Survey. Charts of Lake Champlain, Hudson River and New York Bay.

Reports:
- Chief of Engineers, United States Army.
- State engineer and surveyor of New York.
- St. Louis River water power project.
- Lakes and Gulf waterway, by L. E. Cooley, C. E.

Maps of surveys of lakes in Oswego Basin.

Letter: Prof. N. T. Clarke (lakes in Oswego Basin).

No. 3.—*Table showing comparisons of areas of lakes and watersheds, as figured by United States Deep Waterways Commission and as previously used.*

Name of lake.	Area of water surface (square miles).		Area of watersheds (square miles).		Area of aggregate basin (square miles).	
	United States Commission.	L. Y. Scher-merhorn.	United States Commission.	L. Y. Scher-merhorn.	United States Commission.	L. Y. Scher-merhorn.
Superior	a 31,800	31,200	48,600	51,600	80,400	82,800
Michigan	22,400	22,450	45,700	37,700	68,100	60,150
Huron	b 23,200	23,950	52,100	32,500	75,300	56,450
St. Clair	c 495	460	6,320	8,400	6,815	8,860
Erie	d 10,000	9,975	24,480	23,000	34,480	32,975
Ontario	e 7,450	f 7,240	25,530	21,600	32,980	28,840
Total area of all basins					298,075	270,075

a Lake Superior includes the St. Marys River to the Sault Ste. Marie.
b Lake Huron includes the St. Marys River from Sault Ste Marie to the mouth, and Georgian Bay.
c Lake St. Clair includes the St. Clair and Detroit rivers.
d Lake Erie includes the Niagara River to the falls.
e Lake Ontario includes the Niagara River from the falls to the mouth, and St. Lawrence River from the head to head of Galops Rapids.
f Lake Ontario probably does not include any of the St. Lawrence River.

Tables showing the water and land areas, with elevations, and the areas of the different subdivisions.

No. 4.—LAKE SUPERIOR.

Description:
Terminals—West end at mouth of St. Louis River; east end at Sault Ste. Marie.
Elevation—Standard low water, 600.69 feet; standard high water, 604.76 feet.
Limits—Latitude, 46½° to 49° north; longitude, 84½° to 92½° west.
Length—354 miles on right line (from St. Louis Bay to Michipicoten Bay).
Breadth—162 miles on right line (about on meridian 86° 40′ west).

Area:	Sq. miles.	
Area of water surface		31,800
Area of watershed—		
Ontario	30,780	
Minnesota	6,800	
Wisconsin	3,160	
Upper Michigan	7,860	
		48,600
Total area of basin		80,400

Memoranda:
Area of all islands, 620 square miles.
Area of detached bays and St. Marys River, 1,450 square miles (St. Marys River to Sault Ste. Marie, 40 square miles).
Lake Nepigon—
Elevation (Dawson), 854 feet.

Area of water surface	1,730
Area of watershed	6,460
Total area of basin	8,190

St. Louis River—
Elevation at head of rapids above Thompson, Minn., 1,173 feet.
Area of basin above Fond du Lac (from water power report by J. Birkinbine, C. E.) 3,721

NOTE.—All elevations are given in feet above mean tide at New York City in this and the following tables.

No. 5.—LAKE MICHIGAN.

Description:
Terminals—South end at parallel 41° 30′ north; north or east end at meridian through Mackinaw City Light-House, about 84° 39′.
Elevation—Standard low water, 579.60 feet; standard high water, 584.34 feet.
Limits—Latitude, 41½° to 46½° north; longitude, 84½° to 88° west.
Length—316 miles on right line (from shore line south end, at 87° 30′, to north shore line, at 85° 45′).
Breadth—118 miles on right line (about 45° 25′ north).

Area:	Sq. miles.	
Area of water surface		22,400
Area of watershed—		
Michigan	28,500	
Wisconsin	14,200	
Indiana	2,300	
Illinois	700	
		45,700
Total area of basin		68,100

Tables showing the water and land areas, with elevations, etc.—Continued.

No. 5.—LAKE MICHIGAN—Continued.

	Sq. miles.
Memoranda:	
Area of islands	140
Area of detached bays, etc.	1,930
Lake Winnebago—	
Elevation, 750 feet.	
Area of water surface	210
Area of watershed	5,840
Total area of basin	6,050
Grand River—	
Elevation at Grand Rapids, 586.6 feet.	
Area of basin above Grand Rapids	4,870
St. Joseph River—	
Elevation at South Bend.	
Area of basin above South Bend, Ind.—	
Michigan	2,000
Indiana	1,550
Total area of basin	3,550

No. 6.—LAKE HURON.

Description:
Terminals—North end at Sault Ste. Marie; west end at meridian through Mackinaw City Light House; south and east end at parallel through Port Huron, just below mouth of Black River.
Elevation—Standard low water, 579.6 feet; standard high water, 581.34 feet.
Limits—Latitude, 43° to 46½° north; longitude, 79½° to 84½° west.
Length—207 miles on right line (from Port Harris to Drummond Island).
Breadth—101 miles on right line (about 44° 35′ north).

	Sq. miles.
Area:	
Area of water surface	23,200
Area of watershed—	
Ontario	35,400
Michigan	16,700
	52,100
Total area of basin	75,300
Memoranda:	
Area of islands	1,700
Area of detached bays, etc.—	
Georgian Bay	5,600
North Channel	1,600
St. Marys River	150
Saginaw Bay	1,050
Total area	8,400
Lake Nipissing—	
Elevation (Ells & Barlow), 642 and 649.5 feet.	
Area of water surface	330
Area of watershed	3,600
Total area of basin	3,930
Lake Simcoe—	
Elevation (public works profile), 714 feet.	
Area of water surface	300
Area of watershed	1,750
Total area of basin	2,050
Saginaw River, area of basin above Saginaw	6,000

No. 7.—LAKE ST. CLAIR.

(Including St. Clair and Detroit rivers.)

Description:
Terminals—North and west end at parallel through Port Huron just below mouth of Black River; east end at parallel through Bar Point, mouth of Detroit River.
Elevation—Lake St. Clair, standard low water, 574.26 feet; standard high water, 578.04 feet.
Limits—Lake St. Clair, latitude 42½° to 42¾°; longitude 82⅛° to 83°.
Length—St. Clair River, 37 miles (from United States Ship Canal to Port Huron); Lake St. Clair, 26 miles (on right line about 82° 45′); Detroit River, 27 miles (from Wind Mill Point to parallel through Bar Point); Lake St. Clair, 24 miles (on right line about parallel 42° 25′).

	Sq. miles.
Area:	
Area of water surface—	
St. Clair River	15
St. Clair Lake	445
Detroit River	35
Total area of water surface	495

Tables showing the water and land areas, with elevations, etc.—Continued.

No. 7.—LAKE ST. CLAIR—Continued.

Area—Continued.		Sq. miles.
Area of watershed—		
Ontario		4,160
Michigan		2,160
Total area of watershed		6,320
Total area of basin		6,815
Memoranda:		
Area of islands		80

NOTE.—The area of St. Clair River is taken from Port Huron to Point Aux Cheves.

No. 8.—LAKE ERIE.

Description:
Terminals—West end at mouth of Detroit River; east end at Niagara Falls.
Elevation—Standard low water, 571.35 feet; standard high water, 575.20 feet.
Limits—Latitude 41½° to 43° north; longitude 78¾° to 83¼° west.
Length—239 miles on right line (from Buffalo via Point Pelee to west end).
Breadth—59 miles on right line (from Ashtabula to Point Talbot).

Area:		Sq. miles.
Area of water surface		10,000
Area of watershed—		
Ontario	5,480	
Ohio	11,950	
Michigan	2,990	
New York	2,210	
Indiana	1,270	
Pennsylvania	580	
		24,480
Total area of basin		34,480
Memoranda:		
Area of islands in Niagara River		29
Area of islands in Lake Erie		55
Niagara River—		
From head to the Falls, area of water surface		21
Area of watershed—		
New York	789	
Ontario	420	
		1,209
Total area of basin		1,230

No. 9.—LAKE ONTARIO.

Description:
Terminals—West end at Niagara Falls; east end at head of Galops Rapids, St. Lawrence River.
Elevation—Standard low water, 244.53 feet; standard high water, 249.04 feet.
Limits—Latitude, 43½° to 44½° north; longitude, 76° to 80° west.
Length—193 miles on right line (Burlington Bay to Sacketts Harbor); 53 miles on right line (about on meridian 77° 35′ west.)

Area:		Sq. miles.
Area of water surface—		
Niagara River	5	
St. Lawrence River	185	
Lake Ontario	7,260	
		7,450
Area of watershed—		
Ontario	11,255	
New York	14,275	
		25,530
Total area of basin		32,980
Memoranda:		
Trent River—		
Elevation Balsam Lake summit level, Trent Valley route, 835 feet.		
Area of basin above mouth		4,750
Genesee River—		
Elevation Genesee-Allegheny Canal summit, 1,490 feet.		
Area of basin above mouth (from State survey)		2,446
Black River—Area of basin above Watertown		1,900
Oswego River—Area of basin above mouth		5,000

Tables showing the water and land areas, with elevations, etc.—Continued.

No. 9.—LAKE ONTARIO—Continued.

Area and elevation of lakes in Oswego basin.

Name.	Area.	Elevation
	Sq. miles.	*Feet.*
Lake Oneida	80	369.
Lake Seneca	68	442.
Lake Cayuga	66	379.
Lake Canandaigua	16	682
Lake Skaneateles	14	862
Lake Crooked (or Keuka)	27	720
Lake Owasco	10	705
Lake Onondaga	5	360
Lake Otisco	4	.....
Lake Cazenovia	3	1,177

No. 10.—LAKE CHAMPLAIN AND OTTAWA RIVER.

Lake Champlain.

Description:
Terminals—South end at Whitehall; north end at St. Johns on Richelieu River.
Elevation—Low water, 95.03 feet; high water, 103.78 feet.
Length—125 miles (from Whitehall to St. Johns); breadth, 13 miles.

Area:		Sq. miles
Area of water surface		40
Area of watershed—		
Quebec	740	
Vermont	4,270	
New York	2,950	
		7,96
Total area of basin		8,36
Memoranda:		
Lake George—		
Elevation low water, 320 feet.		
Area of water surface		5
Richelieu River—		
From International Boundary to St. Johns, area of water surface		1

Ottawa River.

Description:
Terminals—From headwaters to mouth at Isle of Montreal.
Elevations—At Ottawa, by Rideau Canal, 116 feet; by Ottawa River, 130.5 feet; Lac des Quinz (Dawson), 848 feet; Lake Temiscaming (Dawson), 588 feet; mouth of Matawan River (Ells & Barlow), 499–513 feet.

Area:		
Basin—		Sq. miles.
From headwaters to mouth of Matawan River		18,43
From mouth of Matawan River to Ottawa City		27,16
From Ottawa City to mouth of river		10,88
Total area of basin		56,47

No. 11.—ST. LAWRENCE RIVER.

[Omitting Ottawa and Champlain basins.]

Description:
Terminals—Head taken at Galops Rapids; east end at line across mouth at Pointe des Monts.
Elevations—

Location.	Standard low water.	High water.
	Feet.	*Feet.*
Ogdensburg	244.28	248.57
Lake St. Francis, at Valleyfield	153.50	155.94
Lake St. Louis, at Melocheville	70	77.50
Montreal	23.10	35.78

Area:		Sq. miles.
Area of water surface		5,395
(Area Lake St. Francis, 70 square miles; Lake St. Louis, 57 square miles.)		
Area of watershed—		
New York	3,605	
Ontario	620	
Quebec	124,345	
Vermont	615	
		129,385
Total area of basin		134,780

Tables showing the water and land areas, with elevations, etc.—Continued.

No. 11.—ST. LAWRENCE RIVER—Continued.

		Sq. miles.
Memoranda:		
Divisions of the St. Lawrence—		
From Galops Rapids to Montreal, area of water surface		220
Area of watershed—		
New York	3,800	
Ontario	620	
Quebec	1,290	
		5,710
Total area of basin		5,930
From Montreal to Quebec, area of water surface		375
Area of watershed—		
Quebec	36,855	
Vermont	615	
New York	5	
		37,475
Total area of basin		37,850
From Quebec to mouth, area of water surface		4,800
Area of watershed—Quebec		86,200
Total area of basin		91,000
Lake St. John (elevation, 293 feet)—		
Area of water surface		350
Area of watershed		23,150
Total area of basin		23,500
Little Montreal River—		
Area of that part of basin lying south of line from St. Johns to La Prairie, Quebec		105
New York		3
Total area		108

No. 12.—HUDSON RIVER.

Description:
Terminals—Head waters up about 44° north parallel; mouth at New York City, Battery Park.
Elevations—Troy Dam, mean low tide, 3.37 feet; mean high tide, 4.17 feet; Fort Edward, low water, 116.4 feet; Champlain-Hudson divide, 146 feet; Black-Mohawk summit level of canal at Boonville, 1,122.7 feet; Onelda-Mohawk summit level of Erie Canal at Rome, 429.7 feet.

Area:		Sq. miles.
Area of water surface from Troy Dam to mouth		140
Area of watershed—		
New York	12,250	
New Jersey	180	
Vermont	520	
Massachusetts	175	
Connecticut	15	
		13,140
Total area of basin		13,280
Memoranda:		
Divisions of the Hudson—		
Hudson River above Fort Edward, area of basin		2,790
Hudson River above Troy Dam (exclusive of Mohawk), area of basin—		
New York		4,010
Vermont		520
Massachusetts		160
Total area of basin		4,690
Hudson River from Troy Dam to mouth—		
Area of water surface		140
Area of watershed—		
New York	4,760	
New Jersey	180	
Massachusetts	15	
Connecticut	15	
		4,970
Total area of basin		5,110
Mohawk River—		
Area of basin above Cohoes		3,480
Area of basin above Amsterdam		3,180

Tables showing the water and land areas, with elevations, etc.—Continued.

No. 13.—GULF OF ST. LAWRENCE AND NEW YORK BAY.

Gulf of St. Lawrence.

Description:
Terminals—Mouth of St. Lawrence River at Pte de Monts; Straits of Belle Isle about at
Norman; at a line from Cape Ray to Cape North.
Limits—Latitude, 46° to 51½°; longitude, 56° to 67°.

Area:	Sq.
Area of water surface	
Area of watershed	
Total area of basin	1
Area of principal islands in Gulf	

New York Bay.

Description:
Terminals—Mouth of Hudson River at the Battery, New York City; line from Throgs
across Long Island Sound to Willets Point; line from Sandy Hook to west end Rock
Beach.

Area:	Sq.
Area of water surface	
Area of watershed—	
New Jersey	2,345
New York	575
Total area of basin	

EXHIBIT B 4.

EFFECTS OF GALES ON LAKE ERIE.

By WM. T. BLUNT, United States Assistant Engineer.

INTRODUCTION.

Of all the five Great Lakes, Lake Erie shows the largest fluctuations of surface in heavy winds. The cause is readily seen. Its axis extends WSW. and ENE. over its main body, with a sharp turn at the islands to W. by N. and E. by S. As hard winds of long duration are almost invariably from SW. or NE., and as the lake is, on the whole, comparatively shoal, the effect of the wind will be at a maximum. Aside from this, the shallowness of the lake and consequent danger to navigators, and the fact that the greater portion of water traffic from the northwest leads directly to its shores, tend to make changes of level more noticeable and important, even were they not larger than on other lakes.

Strong westerly and easterly winds are quite frequent, as nearly every storm crossing the country, whether from the Saskatchewan, Rocky Mountain, or Gulf region, passes near enough to Lake Erie to be felt. Even the West India hurricanes, which usually follow up the Atlantic coast, extend their influence as far as this lake, and occasionally, as in October, 1893, veer across and pass directly over it.

Generally speaking, if the storm center (indicated by lowest barometer) pass to the northward of Lake Erie, the most severe wind will be from the westward; if it pass to the southward, severe easterly winds will result.

By far the greater number of important disturbances pass to the northward, consequently westerly gales are the more frequent. These usually occur in the fall of the year when vessels are endeavoring to close the season with a "few more" trips, so that their importance is naturally magnified over that of easterly gales, which more often occur in the early spring before navigation fully opens.

The effect of westerly winds upon the water surface is generally greater than that of easterly winds. The storm center approaching from the westward causes the gale to begin at Toledo earlier than at Buffalo; consequently the westerly gale pushes the water ahead of it, while the easterly gale draws the water toward it. In addition to this,

[1]Prepared for the United States Deep Waterways Commission, Toledo, April, 1896, accompanied by three sheets of tracings.

the barrier formed by the close line of islands near the west end undoubtedly acts in the same direction, partially turning back the broad wall of water from the eastward, but allowing the passage of the smaller amount from the westward into the larger expanse to the eastward.

It is generally true that in each year the most severe easterly gale occurs in or near April, raising the water 4 to 6 feet at the west end of the lake and lowering it about the same at the east end; and the most severe westerly gale in or near October, lowering the water 7 to 8 feet at the west end, and raising it 5 to 8 feet at the east end. At other times of year equally extreme conditions sometimes obtain, but not as a rule. Changes of 2 to 4 feet (or a total of 4 to 8 feet in the length of the lake) are of so frequent occurrence as to be considered common, and not heretofore matter of special record.

Reliable records of water levels began in 1859 at Cleveland, somewhat later at Erie and Buffalo, and quite recently at Ashtabula, Monroe, and West Sister Island. None of these records are entirely complete as to extremes reached between the regularly required three readings per day; consequently in all except general studies of lake levels we are confronted at once by that common bugbear "insufficient data."

For a detailed study of storm effects, the record of variations along the north shore is also a prime necessity. So far as I have been able to learn, there is no such record.

The datum plane adopted by the United States Lake Survey for reduction of its soundings was the mean level of the lake during the sixteen years 1860 to 1875, inclusive, as observed on the Cleveland gauge; and while the mean level will be varied somewhat by the addition of each year's observations, it may be noted that the mean for the thirty-five years 1860 to 1894, inclusive, is practically the same as that for 1860 to 1875.

Before the determination of lake elevations above mean tide at New York, a "plane of reference" was used for Lake Erie, which purported to be the high water of June, 1838, as fixed with more or less accuracy at Cleveland. This assumed horizontal plane was referred to bench marks, and the mean level (1860–1875) was found to be 2.34 feet below it. It is still quite generally used for convenient comparison with past records. Since the connection of the Hudson River levels with those of the lakes in 1875 the reference to mean tide at New York has come into general use. While this reference plane is itself determinate, and while instrumental levels have connected it with the east end of Lake Ontario, the rigid determination of points along the lakes has never been made, so that all heights referred to mean tide must still be held as approximate. In the survey of the Northern and Northwestern Lakes the assumption was made that the mean surface of each lake was level within the limit of possible instrumental errors in traversing its length, and all heights and gauges west of Oswego have been based on this assumption. The actual period of observations used to transfer the level by lake surface was from May 11 to August 31, 1875; and while it is certain that the eminent officer then in charge of the survey took every precaution to obtain accurate results, it will still be a matter of scientific if not of practical interest to have a verification of these elevations. When we consider the marked effects of even light winds on the surface of Lake Erie, the very decided effects of strong continuous winds, and the extraordinary effects of gales, in connection with the fact that the great preponderance of winds is from the westward, the proposition that even the mean surface is level appears somewhat clouded; it at least requires verification.

The following table is compiled from the office records of the Weather Bureau, at Toledo, Ohio:

[From continuous self-registering record, beginning in June, 1891.]

Month.	No. of months.	Total wind movement during the months named (miles).	Proportions of total movement from different points of compass (per cent).															
			N.		NE.		E.		SE.		S.		SW.		W.		NW.	
			Miles.	Hours.	Miles.	Hours.	Miles.	Hours.	Miles.	Hours.	Miles.	Hours.	Miles.	Hours.	Miles.	Hours.	Miles.	Hours.
January, 1892-95	4	32,718	5	7	3	4	5	5	4	5	8	7	25	21	30	30	20	20
February, 1892-95	4	31,693	6	7	7	5	9	11	8	8	4	5	20	17	17	18	29	29
March, 1892-95	4	35,351	7	8	10	10	13	15	8	10	7	7	18	14	13	16	24	20
April, 1892-95	4	34,891	6	8	10	11	18	20	15	14	6	5	16	12	10	11	19	19
May, 1892-95	4	30,651	9	9	5	6	12	13	9	9	10	10	20	17	15	16	20	20
June, 1891-95	5	30,523	5	5	10	9	16	16	10	12	6	7	17	14	20	20	16	15
July, 1891-95	5	30,562	7	8	8	8	11	12	7	8	7	8	18	15	23	23	19	16
August, 1891-95	5	28,766	9	11	13	11	14	14	10	11	6	8	15	13	18	16	15	14
September, 1891-95	5	33,914	6	7	7	7	11	13	12	9	8	9	19	16	19	19	18	18
October, 1891-94	4	28,676	7	8	4	5	7	8	6	9	7	8	24	19	20	21	25	21
November, 1891-94	4	32,524	7	9	3	4	2	4	5	7	10	9	29	23	17	17	27	27
December, 1891-94	4	34,483	5	8	5	6	2	3	6	6	10	10	30	32	17	18	16	16
Average	1	7,399	6½	8	7	7	10	11	8½	9	7½	7½	21½	18	18½	19	20½	19½

NOTE.—During 1 per cent of time wind was less than 3 miles per hour.

Month.	Average wind movement per month (miles).	Proportions along axis of Lake Erie (per cent).			
		NE. and E.		SW. and W.	
		Miles.	Hours.	Miles.	Hours.
January, four years	8,180	8	9	55	51
February, four years	7,923	16	16	37	35
March, four years	8,838	23	25	31	30
April, four years	8,723	28	31	26	23
May, four years	7,663	17	19	35	33
June, five years	6,105	26	25	37	34
July, five years	6,112	19	20	41	38
August, five years	5,753	27	25	33	29
September, five years	6,783	18	20	38	35
October, four years	7,169	11	13	44	40
November, four years	8,131	5	8	46	40
December, four years	8,621	7	9	56	50
Average	7,399	17	18	40	37

Resultant movement: S. 84° W. 27 per cent of total, or 1,998 miles per month.
Resultant direction: West. 23 per cent of total, or 166 hours at velocity of 12 miles per hour in a 30-day month.

The following points are worth noting:

First. The total wind movement from SW., W., and NW. is 60½ per cent of the whole, or one-half more than that from the five other points, and covers 56½ per cent of the time, or one-third more than that from the five other points.

Second. The proportion of movement to time is in excess in the SW., W., and NW. winds, while in the five other points time is in excess of movement. In other words, the velocities in westerly winds are greater than in those from other quarters.

Third. The only winds having any decided effect on the lake surface as a whole are those from SW. and W., and from NE. and E. These are compared in the second table above. Both movement and time from SW. and W. are more than double those from NE. and E. Time predominates in easterly winds, while the reverse is true in westerly winds.

Fourth. The resultant movement and direction in the average month are most decidedly from the westward. In order to vividly comprehend the meaning of this, we may imagine a particle of matter moving absolutely with the wind. It follows exactly the movement of each change, and at the end of the month, having traveled 7,400 miles, it is found 2,000 miles nearly due east from its starting point.

While these deductions are based on the record at Toledo alone, they are fairly indicative of the conditions existing at other Lake Erie stations, as is shown by a glance at such records as are at hand.

At all Lake Erie stations having continuous self-registering instruments, in the year 1894, both the resultant movements and directions were from the southwest quadrant, the resultant movement being from 25 to 50 per cent of the total movements.

This naturally tends to keep the mean level of the east end of the lake higher than that of the west end. No current has ever been determined to show a fall as an offset to this tendency.

However this may be, we must assume for the present the following figures:

	Feet.
Mean level, 1860–1875, on Lake Erie above mean tide at New York	572.86
High water of 1838 on Lake Erie above mean tide at New York	575.20

And that the mean levels used at all Lake Erie harbors are actually at the same height above mean tide.

On the general subject of Lake Erie levels, it is well here to refer to an extremely valuable and exhaustive paper written in 1859 by Charles Whittlesey and published in the Smithsonian Contributions to Knowledge, Vol. XII. It is entitled "Fluctuations of level in the North American lakes," and contains the results of his researches among records and traditions as far back as 1788. He refers his levels to the miter sill of the enlarged Erie Canal at Buffalo, and his context shows this to have been 11.4 feet below high water of June, 1838.

The mean level of Lake Erie for November, 1895, was lower by three-tenths foot than that for any other month since the record began in 1859, viz, 4.4 foot below high water of 1838; and in only nine years of that period has the lowest monthly mean been as low as the highest of 1895, which was in June, 3.5 feet below high water of 1838.

Referring now to Mr. Whittlesey's paper, his tables show that the only records of monthly means between 1788 and 1857 which were as low as that of November, 1895, were:

	Above miter sill.	Below high water of 1838.
	Feet.	*Feet.*
June, 1819, Cleveland	6.3	5.1
Winter of 1818-19, Detroit (Dr. Houghton's observation)	4.7	6.7
January, 1840	6.9	4.5
January, 1841	6.7	4.7
March, 1841	6.6	4.8
October, November, and December, 1841	6.9	4.5
February, 1846	7	4.4
March, 1846	6.9	4.5

Of these, even, only that of 1819 is more than slightly lower than that of November, 1895. The present low stage of water is therefore unequaled in the past fifty years, and seldom reached since 1819.

Speaking of the necessity of daily registers of level on each lake, Mr. Whittlesey says:

Government has, however, through its light-house keepers, the means of procuring perfect registers of water levels on all the lakes, with the least possible expense; and there would be little difficulty in pointing out numerous practical results that would justify such a system of observations, without regarding the unseen benefits that always follow the acquisition of scientific knowledge.

Again, as to changes in surface:

In discussing the data here presented, it is apparent that the surface of the lake is not strictly level, and thus there are discrepancies as to the time of high and low water at different places. The form of the coast at Buffalo is such that the height of water is affected by it in connection with certain winds. Those from the east and northeast keep back the waters and cause a depression that may be observed for one or two months at a time. The reverse occurs with prevailing winds from the west and southwest. The waters driven eastward between two shores constantly approaching each other are raised above the general surface like the tides in the Bay of Fundy.

On the 18th of April, 1848, it appears from the register of Mr. Lothrop that a gale from the northeast reduced the level of the lake to a point 15 feet 6 inches below the surface of October 18, 1849, when a terrible storm occurred from the southwest.

Following is a tabular statement of information relating to various storms of the past ten years and to their effect on the lake surface.

Table showing effects of gales on Lake Erie.

[Heavy-faced figures show the extreme change specially observed; in the absence of this information, the light-faced figures show the greatest change recorded. f and r represent fall and rise from prevailing level; this level is shown as + above, — below. Mean level 1860-1875.]

WESTERLY.

Date.	Prevailing level.	Amherstburg, Detroit River.	Monroe.	Toledo.	West Sister Island.	Cleveland.	Ashtabula.	Erie.	Buffalo.	Remarks.
Oct. 14, 1886	+0.4			f. 7.4					r. 6.9	From Kansas, passed N. of lake; three schooners foundered; thirteen lives lost; Buffalo, maximum 63 miles; average 53 for four hours.
Oct. 3, 1887				f. 7.0, p. m		f. 0.6, 7 a. m		r. 3.0 11 a. m	r. 4.6, 1 p. m. / r. 7.0, weather report.	From Saskatchewan, passed N. of Mackinaw. In October, 1887, nine low areas crossed lakes; four schooners, one tug, and seven lives lost.
Dec. 28, 1887 / Dec. 29. 1887	— .4					f. 0.7, noon		r. 2.4, 12 and 7 p. m.	r. 3.0. 7 p. m., 28th.	
Dec. 27, 1888	— .4					f. 0.3, noon		r. 1.4, 7 p. m	r. 2.6	
Jan. 10, 1889	— .4			f. 7.1, weather record.		f. 0.9, noon		r. 3.5, 2 a. m	r. 8.2, 3 a. m., estimated.	From Texas, passed over Alpena; maximum, 55 miles; extreme, 82.
Feb. 19, 1889	— .5					f. 0.6, 7 a. m. and 12.		r. 0.5, all day	r. 2.5, 2 a. m.	Maximum, 62 miles, Buffalo.
May 28, 1889	— .3					f. 0.1		r. 0.7	r. 3.4, 10 p. m	Maximum, 54 miles, Buffalo; 36 miles, Toledo.
Dec. 22, 1889	— .7					f. 0.7. noon		r. 2.6, noon	r. 4.5, noon.	Extreme, 72 miles, Buffalo; 58, Toledo.
Jan. 13, 1890	— .3			f. 5.0, weather record.		f. 3.0, 7 p. m.		r. 3.9, 2.30 p. m.	r. 7.9, 2.30 p. m.	Maximum, 90 miles; extreme, 100, Buffalo.
Jan. 20, 1890	— .3					f. 0.8, noon		r. 2.3, noon. / r. 2.8, 10 p. m., 21st.	r. 4.7, 2 p. m. / r. 4.4, 2 p. m., 21st.	Maximum, 66 miles, Buffalo.
Apr. 9, 1890	+ .5					f. 0. 9, 7 p. m		r. 1.6, 5 p. m.	r. 3.7	
Mar. 13, 1891	— .1					f. 0.9, 7 p. m		r. 2.1, 9.30 p. m.	r. 3.3, 7 p. m	
Nov. 17, 1891	—1.5					f. 0.8, 7 p. m		r. 2.4, noon / r. 2.2, 7 p. m	r. 4.1, 7 p. m	Maximum, 54 miles, Buffalo.
Jan. 7, 1892	—1.5					f. 0.8, 7 p. m.		r. 1.4, 12 and 7 p. m.	r. 3.4, 3.30 p. m.	
Sept. 15, 1892	— .1					f. 0.3, 7 a. m., 7 p. m.		r. 2.0, 3 a. m.	r. 3.9, 3 a. m.	
Oct. 29, 1892	— .6		f. 6.7, 6 a. m.	f. 6.9		f. 1.1, 7 a. m.		r. 3.3, 4 a. m.	r. 5.2, 4 a. m.	From Manitoba, passed over Lake Huron; maximum 60 miles, Cleveland.
Nov. 8, 1892	— .8					f. 0.6, 7 p. m.		r. 2.4, 4 a. m.	r. 4.0, 2.30 a. m.	

Oct. 14, 1893	— .7	f. 5.0	f. 6.8	f. 6.8	f. 5.8	f. 1.2	f. 1.3	r. 2.6	r. 5.3	West India hurricane. See special report.
Nov. 22, 1893	—1.2	f. 1.3, 7 p. m.	f. 2.9, 7 p. m.	f. 3.3, 4 p. m.		f. 0.8, 7 p. m.	f. 0.1, noon.. r. 0.5, 5 p. m.	r. 1.8, noon ..	r. 3.4, 3 p. m.	From Saskatchewan, passed N. of lake; maximum 30 to 38 miles SW.
Nov. 28, 1893	—1.2	f. 1.3, 7 a. m.	f. 2.8, 7 a. m.	f. 2.8		f. 0.8, all day.	r. 0.4, 7 a. m.	r. 1.8, 7 a. m.	r. 4.9, 5 a. m.	From NW. over Texas and Lake Huron; maximum 28 miles, Toledo.
Nov. 3, 1894	—1.1		f. 3.6, 7 a. m.		f. 3.9, 7 a. m.	f. 0.9, 7 a. m	r. 0.8, 7 a. m	r. 2.6, 10.30 a. m.	r. 5.5, 11 a. m.	From Texas, passed N. of lake; maximum 35, Toledo.
Jan. 22, 1895	—1.4		f. 2.8, 7 a. m		f. 2.2, 7 a. m. and noon.	f. 0.3, 7, 12, and 7.	r. 0.5, 7 a. m.	r. 1.8, noon..	r. 2.8, 7 a. m	From Texas, passed over Lake Michigan; maximum 42, Toledo.
Jan. 26, 1895	—1.4		f. 3.4, 7 p. m.		f. 2.6, 7 p. m.	f. 0.8, 12 and 7 p. m.	r. 0.8, 7 a. m.	r. 1.2, 7 p. m.	r. 3.2, 11 a. m.	From Gulf, passed over Michigan; maximum 43 miles, Toledo.
Sept. 29, 1895	—1.3		f. 2.5, 7 a. m., 7 p. m.		f. 2.7, 7 a. m., 7 p. m.	f. 0.7, 7 a. m., 12.	r. 0.1, 7 a. m.	r. 0.8, 7 a. m.	r. 2.8, 6 a. m.	From NW., passed over Mackinaw.
Oct. 28, 1895	—1.8	f. 2.5, 7 a. m	f. 3.8, 7 a. m.			f. 1.2, noon ..	r. 0.5, 7 a. m. f. 0.2, noon..	r. 2.4, 10.30 a. m.	r. 3.8, 10 a. m.	From NW., passed over Lake Huron; maximum 36 W., SW. at Toledo, 26th to 29th, inclusive.
Nov. 26, 1895	—1.9	f. 1.3, noon ..	f. 5.6, noon..	f. 5.3, 1 p. m.	f. 4.5..... f. 3.6, at Port Clinton.	f. 1.4, noon..	r. 1.0, 7 a. m. f. 0.2, noon..	r. 3.7, 11 a. m.	r. 7.5, 11 a. m. f. 1.2, 4 p. m.	From SW., passed just W. of Toledo; maximum 72 miles, extreme 81 miles; barometer at Toledo lowest except two on record; rose 1.1 inches in 21 hours.
Dec. 31, 1895	—1.8		f. 4.1, 7 a. m.			f. 1.2, 7 a. m.	r. 1.0, 7 a. m.	r. 3.7, 5 a. m.	r. 6.6, 4 a. m.	From Gulf; maximum 56 miles, Buffalo.
Feb. 11, 1896	—1.7	f. 3.4, 7 a. m..	f. 5.6, 7 a. m.	f. 4.3		f. 0.9, noon.	r. 1.2, 7 a. m.	r. 2.1, 7 a. m.	r. 4.6, 2 a. m.	From NW.; maximum 44 miles, extreme 56 miles.

EASTERLY.

Apr. 18, 1887	+1.0					r. 1.3, noon ..		f. 0.9, noon ..	f. 2.3, 1 and 7 p. m.	
June 28, 1888	+ .3			r. 1.5		r. 0.8, noon ..		f. 0.5 noon ..	f. 1.6, noon ..	
Jan. 5, 1889	— .4					r. 0.7, 12 and 7 p. m.		f. 0.4, 7, 12, 7 .	f. 1.8, noon ..	
Nov. 27, 1889	— .9					r. 0.4, noon ..		f. 3.7, 9.30 a. m.	f. 1.5, 7 a. m..	From Colorado; maximum, 28 miles
Dec. 3, 1889	— .7					r. 0.5, 7 a. m .		f. 1.2, 3 p. m.	f. 2.5, noon ..	
Feb. 19, 1890						r. 0.2, 7 a. m .		f. 1.9..... r. 2.0, 5 a. m., 20th.	f. 2.1, 5 a. m . r. 2.1, 7 a. m., 20th.	
Sept. 10, 1890	+ .1					r. 0.2		f. 0.8, 3.20 p. m.	f. 1.8, 7 a. m .	
Dec. 3, 1890	— .2					r. 0.7, 7 a. m		f. 0.6, 7 a. m .	f. 1.7, 7 a. m .	
Feb. 7, 1891	— .4					r. 0.1, 7 p. m .		f. 0.9, 12 and 7 p. m.	f. 1.9, 7 p. m .	
Mar. 19, 1891	— .1					r. 0.5, noon ..		f. 1.1, 12 and 7 p. m.	f. 2.2, 7 p. m.	
Mar. 26, 1891	— .1					r. 0.5, 12 and 7 p. m.		f. 1.2, 12 and 7 p. m.	f. 2.0, 7 p. m.	

Table showing effects of gales on Lake Erie—Continued.

EASTERLY—Continued.

Date.	Prevailing level.	Amherstburg, Detroit River.	Monroe.	Toledo.	West Sister Island.	Cleveland.	Ashtabula.	Erie.	Buffalo.	Remarks.
Oct. 12, 1891	—1.1					r. 0.2, 7 p. m.		f. 0.7	f. 1.7, 7 p. m.	
Dec. 24, 1891	—1.3					r. 0.8, 7 a. m.		f. 0.6, 9 a. m.	f. 1.9, 9.30 a. m.	
Feb. 27, 1892	—1.7					r. 0.4, 7, 12, 7.		f. 0.9, 7, 12, 7.	f. 1.9, 3 p. m.	
Mar. 1, 1892	—1.5					r. 0.3, 7 a. m.		f. 1.1, 7 a. m.	f. 2.6, 7 a. m.	
Feb. 2, 1893	—1.5		r. 0.9, 7 p. m.			r. 0.3, 7 p. m.	f. 0.3, 7, 12, 17	f. 1.0 (?), 8 p. m.	f. 1.7, 7 p. m.	
Feb. 17, 1893	—1.5		r. 1.6, 7 p. m.			r. 0.7, 7 p. m.	f. 0.3, 7, 12, 7.	f. 1.0, 4 p. m.	f. 1.7, 7 p. m.	
Mar. 22, 1893	—1.2		r. 1.8, 12 and 7 p. m.			r. 0.5, 12 and 7 p. m.	f. 0.0, 7, 12, 7.	f. 0.8, 7 p. m.	f. 1.6, 7 p. m.	
Apr. 20, 1893	—.5	r. 1.6, 7 a. m.	r. 5.5, 7 a. m.	r. 5.9, in night.		r. 0.9, 7 and 12.	f. 0.4, 7 a. m.	f. 0.9, 7 a. m.	f. 2.0, 7 a. m.	From Rocky Mountains passed 300 miles N. of lake; maximum 72 miles, Detroit; 54 miles, Oswego.
Aug. 29, 1893	—.2		r. 0.6, 7 p. m., 28th.			r. 0.7, 7 a. m.		f. 0.2, variable.	f. 3.4, 2 a. m.	From Florida passed near Oswego; maximum 23 miles, Toledo.
Dec. 11, 1893	—1.0		r. 0.9, 7 p. m.			r. 0.2, 7 a. m.	f. 0.5, 5 p. m.	f. 0.4, 7 p. m.	f. 2.0, 9 p. m.	From NW. passed along N. shore; maximum 56 miles, Buffalo; 16 miles, Toledo.
Feb. 12, 1894	—.9		r. 5.1, noon r. 4.8, 7 p. m.	r. 7.9, 5.30 p. m.	r. 3.3, at Port Clinton.	r. 1.7, 7 p. m.	r. 0.0, 7, 12, 5.	f. 2.4, 9 p. m.	f. 5.1, 5 p. m.	From Texas passed over Ohio; maximum 60 miles; extreme 88 miles, Toledo; less than 25 miles, Cleveland; 28, Erie; 40, Sandusky.
Dec. 10, 1894	—1.1		r. 2.0, 7 p. m.		r. 1.6, noon r. 1.4, 7 a. m.	r. 0.2, 12 and 7 p. m.	f. 0.2, 7 a. m. f. 0.4, 5 p. m.	f. 0.8, noon f. 0.6, 7 a. m., 7 p. m.	f. 1.7, 7 a. m.	
Mar. 4, 1895	—1.6		r. 1.7, 7 a. m.		r. 1.1, 7 a. m.	r. 0.8, noon	f. 0.0, 7, 12, 7.	f. 1.0, 7 p. m. f. 0.8, 7 a. m.	f. 2.2, 9 a. m.	From Gulf passed up Ohio Valley S. of lake.
Mar. 30, 1895 Mar. 31, 1895	—1.6		r. 2.3, 7 p. m., 30th.		r. 2.0, 7 p. m., 30th.	r. 0.4, 7 p. m., 30th.	f. 0.2, 7, 12, 7.	f. 0.9, 7, 12, 7, 30th. f. 0.7, 7, 12, 7, 1st.	f. 1.7, 7 a. m., 30th. f. 1.8, 7 a. m., 31st.	No low bar. near; wind resulted from steep temp. gradient. 33° Toledo, 66° Cincinnati; maximum, 39 miles.
Nov. 25, 1895	—1.9		r. 1.7, 7 a. m.	r. 2.3		r. 0.0	f. 0.2, noon	f. 0.6, 7 a. m.	f. 1.5, 7 a. m.	See westerly storm, November 26.
Dec. 11, 1895 Dec. 12, 1895	—1.8		r. 1.2, 7 p. m., 11th. r. 1.4, 7 p. m., 12th.			r. 0.6, noon, 12th.	f. 0.2, 7, 12, 7, 11th.	f. 0.7, 11th... f. 0.9, 12th...	f. 3.6, midnight.	From NW. passed N. of lake.

Three tracings accompany this paper, one showing a chart of Lake Erie with contours of bottom, one the wind movements and their resultants, and the third the changes in surface at different points on the south shore during storms. From the large number of storms tabulated, those of most complete gauge record are selected—twelve westerly and seven easterly gales. The greatest change known at each point from the prevailing general level of the lake is noted for each storm, also the position of that general level relative to mean level.

The regular three readings per day seldom show the maximum change; in one case of record at Buffalo the maximum attained was 5.1 feet higher than the extreme regular reading. It will thus be seen that any comparisons made without the maximum being known will show always less than the actual variations.

Westerly storms.—While in several cases there is a record of the maximum change at each end of the lake, there is but one storm where the record along the south shore is anything like complete. This was the SW. gale of October 14, 1893, which, owing to the favorable conditions for study, was the subject of the following special official report by the writer. (See Annual Report, Chief of Engineers, United States Army, 1894, Appendix D D D 3.)

CLEVELAND, OHIO, *June 20, 1894.*

SIR: I have the honor to submit the following report upon the variations in the surface of Lake Erie during the westerly gale of October 14, 1893:

PRELIMINARY AND GENERAL.

The extent of Lake Erie may be divided into three well-defined basins:

The west basin, west of the "Islands," containing about 1,200 square miles, and having a comparatively flat bottom at 5 to 6 fathoms when away from the immediate vicinity of the shore.

The main basin, between the "Islands" on the west and the narrows at Erie and Long Point on the east, containing about 6,700 square miles, and having a marked shelving bottom, deepening gradually to 14 fathoms.

The east basin, east of the narrows, containing about 2,100 square miles, and having a deep depression of 30 fathoms just east from Long Point Island.

Between the main and east basins lies an extensive flat at 11 fathoms depth, with only a narrow cut of 12 fathoms near the American shore.

The general axis of the lake lies east northeast and west southwest, while that of the west basin makes a decided turn to west by north.

It is a well-known fact that a westerly wind lowers the water surface at the west end of the lake and raises it at the east end, while an easterly wind has the opposite effect. The amount and extent of fall or rise varies with the force and extent of the wind. A fresh local breeze will often change the level locally, while not affecting it materially in the open. A continued, general, and strong wind will have a general effect on the surface curve of the lake, lowering it considerably at the end from which the wind blows and raising it somewhat less at the opposite end. The variations due to this cause are most marked at the extreme ends of the lake, notably at Toledo, Monroe, and Buffalo. At the mouth of Detroit River they are tempered by the continuous supply from that river. At Toledo the record in the past eight years shows an extreme fall of 7½ feet and an extreme rise of 5 feet. As my data are more complete for the west end and for westerly storms, this report will deal more fully with westerly gales and consequent fall at west end of lake than with the opposite.

The variation in the shoal and inclosed west basin in a continued gale is much greater than in the main basin. A high westerly wind for several hours will lower the water in the west basin 2 feet, as shown by gauge at West Sister Island, which is well toward its center. This same wind will lower the water east of the islands only a few tenths.

This change of surface, due to heavy winds, has been many times remarked, usually in a general way, but I have no knowledge of its ever having been discussed on the basis of definite data. It would seem that the questions involved would not only be of great interest from a scientific standpoint, but would be of vital interest to navigators as enabling them to correctly judge of depths and currents during a severe storm. My own observations at the west end of the lake for the past eight years have convinced me that the subject should receive more than passing notice, and it is the purpose of this report to show a reason for that belief. About

once in each year, usually in April, a heavy northeast storm occurs which raises the water 5 feet at the west end of the lake, and also once in each year, usually in October, a heavy westerly gale lowers the water 7 to 7½ feet. These two storms are almost certain to come and to be attended by great loss of property and life. Never until last fall have circumstances permitted me to examine personally or to investigate generally the conditions attending such storms.

CONDITIONS OCTOBER 14, 1893.

On the morning of this day, while the steamer *Swansea* was tied up without steam, cleaning boiler, the wind freshened from northwest and all indications were for the annual low water. As often happens in such cases, the day was full of drawbacks, so that the boat could not leave the pier until 4 o'clock in the afternoon, at which time the water in the river, 5 miles from its mouth, had receded to 7½ feet below mean level. A trip of unusual interest was then made to the bay. In the river, flats were showing where a few days before we had found 8 feet of water. The banks of the Straight Channel, where maps show 6 feet depth around Presque Isle, were 2 feet out of water, and for 2 miles these banks showed above water perfectly straight as if on a canal. Darkness came on as we reached the bay, so that my intention of photographing the view was frustrated. As we reached the main crib in the middle of the bay we found the large Breymann dredge aground in the 17-foot channel and a reflex current rushing back against the gale with such force that the steamer could not be turned and had to remain there over night. By 9 o'clock the water had set back to within 3 feet of its normal level, notwithstanding the gale continued.

It so happened that in many harbors we had inspectors at the time, but it also unfortunately happened that none of them took special measurements of the stage of water, though I obtained from them, with the help of others, a very fair general idea of it. The general level of the lake before and after the storm was 0.7 foot below mean level of 1860–1875 as used for our datum plane. This general level must of course be used in discussing the effects of this storm. The variations from this level at different points, together with notes showing their reliability, are given below:

Place.	Notes.	Time.	Variation.
Amherstburg, inside mouth of Detroit River.	Gauge maintained by Gen. Poe; showed extreme at 4 p. m., and nearly the same at 11 a. m. to 5.30 p. m.	4 p. m.....	—5.0
Monroe.....	Light keeper measured at noon, —6.2 feet, and thinks it was about 0.6 to 1.0 foot lower in the afternoon.	p. m	—6.8
Toledo.....	Measured by writer at Adams street, 5 miles from bay....	3.30 p. m ..	—6.8
	Estimate at mouth of river, by appearance of banks.....	5 p. m.....	—7.3
	Estimate by light-keeper at main crib in bay	4 p. m.....	—6.8
West Sister Island ..	Light keeper walked dry-shod around the pier, where depth at mean level is about 6 feet.	p. m	—5.3
Green Island	Light keeper says 5½ feet below usual; could have walked around pier but for sea.	p. m	—5.3
Sandusky.....	Inspector's estimate at pier, —2.8 feet. Crib light keeper took sounding in boathouse; sounding afterwards at known stage gives—	4 p. m.....	—2.5
Huron.....	Light keeper says at least 3 feet below ordinary; others same; could walk half way to light-house; soundings show—	p. m	—2.8
Vermillion.....	Light keeper estimated 1 foot below bottom of gauge	p. m	—2.3
Black River	Inspector's estimate, 3 feet or more below mean level; others, 4 feet.	p. m	—2.8
Cleveland	Regular gauge reading at 12 and 6 o'clock, each.....	12 m ..... / 6 p. m.....	—1.2
Fairport.....	All say very low; light-keeper thinks 8 to 10 inches below former level.	.....	—1.0
Ashtabula.....	Inspector's gauge: Noon, —0.1; 6 p. m., —1.3	.....	—1.3
Conneaut.....	Inspector's gauge: Noon, 3.4; 4 p. m., +3.4.....	12 m ..... / 4 p. m.....	+3.4
Erie.....	Gauge reading furnished by Maj. Ruffner as extreme.....	1 p. m.....	2.6
Buffalo	.....do.....	10 a. m	5.3

It is also to be noted that both Erie and Buffalo show a minimum gauge of —0.8 and —2.8, respectively, at 2 a. m., giving a range of 8.1 at Buffalo during this storm. It will further be noted in the weather record below that at Buffalo the wind was from the eastward until 2 a. m., and about the same at Erie.

A tracing accompanies this report showing a contour map of Lake Erie and a profile of the water-surface curve along its south shore.

During this storm the weather conditions, as courteously furnished me by the various observers, were as follows:

Toledo.—Light easterly winds on 13th, rain in evening. Wind backed to north and northwest about midnight, increasing in force, and blew from northwest continuously

till 5 p. m., 15th, when it became variable and dropped to 6-mile velocity. Maximum velocity 38 miles northwest at 10.30 a. m., 14th; general velocity, 20 to 30 miles northwest; minimum barometer, 28.46, 2 a. m., 14th.

Sandusky.—Easterly winds, 13th, light. Wind increased and backed to northeast in afternoon. High westerly winds from 2 p. m. to midnight, 14th, and continued till evening, 15th, when shifted to northerly.

Cleveland.—Barometer, midnight 13th, 28.33. At 7 p. m., 13th, increasing southeast wind had backed to northeast 27 miles. At 8 p. m. backed to northwest and increased to 32 miles; backed to southwest 35 miles and reached 46 miles west at 2 a. m., 14th, and 48 southwest at 2.40 p. m., 14th. Minimum barometer 28.20 at 2 a. m., 14th, then rose steadily. Gale continued on 15th from southwest and northwest 41 miles maximum at 2.50 p. m.

Erie.—Wind southeast forenoon of 13th backed to northeast in afternoon. Barometer fell rapidly. Windstorm began early in morning, maximum 34 miles southeast at 4.15. Another windstorm began at 8.30 p. m. and reached maximum of 42 southwest at 10.40 a. m., 14th. High wind began 5.30 a. m., velocity 30 to 35 miles, maximum 42 southwest. Abated after 2.30 p. m., 15th.

Buffalo.—From 5 p. m., 13th, to 2 a. m., 14th, barometer fell 1.05, reaching 27.89, the lowest known here. Wind shifted from northeast to southwest at 3 a. m. and blew a gale till after midnight, 14th, maximum 61 miles southwest at 4.10 p. m., 13th. Gale continued till 4 p. m., 15th.

This storm is noted by the Weather Bureau to have been a typical West India cyclone, developing east of the West Indies. It was one of the exceptional cases, when such a storm passes inland, the storm center being near Charleston on morning of 13th with 60-mile velocity, immediately west of Washington, evening of 13th, 38 to 48 miles velocity, thence passing rapidly over Buffalo and being north of Lake Ontario on morning of 14th. A very steep gradient existed on morning of 14th over the whole country east of Missouri River, which was not dissipated until evening of 15th. Ordinarily all storms approach this region from the westward, so that the gale does not commence at east end of the lake quite as early as at west end. In this case its whole fury struck Lake Erie over its entire length at once. Its unusual course also produced the erratic phenomenon of a "backing" wind holding steadily from one direction (see Toledo record) for forty hours. Many disastrous wrecks occurred, and it is worthy of note that several of the worst were in the vicinity of the "Narrows," before mentioned, between Long Point and the American shore near Erie and Dunkirk. The steamers *Dean Richmond* and *Wocokea* and the schooners *C. B. Benson* and *Riverside* were all lost during this storm, and all in the same locality—at these "Narrows." Seven lives were lost with each of the schooners, which were considered to be seaworthy boats, as both were in the grain trade. Not a soul was saved from the *Richmond*, and but three from the *Wocokea*.

CONCLUSIONS.

It will be observed that while few of the heights are accurate, they carry sufficient reliability to warrant a general discussion of the matter in the light of this crude data, and the hope that it will lead to the obtaining of more definite knowledge and perhaps more sound conclusions. A discussion of other points of interest than those touched upon in this report, though tempting, is, I feel, hardly justified by the data now at hand.

It must also be noted that all data we have was recorded along the south shore of the lake and that the times of record are not coincident, though generally nearly so.

Following now the profile of water and surface in connection with the above data, we find that in the West Basin the fall in the funnel-shaped end, containing Monroe and Toledo, was 6.8 feet; in the open it was 5.3 feet. In the main basin, immediately we passed the Island barrier, the fall was but 2.6 feet for all points until Cleveland is reached, at the widest part of the lake. Here we find a fall of but 1.2 feet, and practically the same at Ashtabula. Between Ashtabula and Conneaut, a distance of 13 miles, we meet a solid wall of water 4.7 feet high, there having been a rise of 3.4 feet at Conneaut. At Erie the rise was 0.8 foot less than at Conneaut, and at Buffalo the highest point reached was 5.3 feet.

The question now at once arises, Do these surface heights along the south shore correctly represent the heights of water in the lake? Assuming it to be so—that is, that the surface is level on each line normal to the shore—then the surplus water in the eastern end of the lake should be about equal to the deficiency in the west end. We find the line of no variation from the normal stage before and after the storm to have been between Ashtabula and Conneaut. The area west of this line is approximately 7,000 square miles, that east of it, 3,000 square miles. In order to make the two quantities equal, the proportion of fall to rise should be as 3 to 7. The records of fall being more numerous, covering larger territory and to a fair extent agreeing among themselves, we may assume a fall of 5.3 feet over 1,200 square miles, 2.6 feet over

1,800 square miles, 1.2 feet over 4,000 square miles, to equal a fall of 2.3 feet over 7,000 square miles; which would give, if our assumption is correct, an average rise of ½ of 2.3 feet=5.4 over 3,000 square miles. This is not borne out by the data, as it is as large as the maximum height at Buffalo, and twice as large as that at Erie. To show its absurdity, we have really an average rise of perhaps 3.7 feet over 3,000 square miles, which leaves unaccounted for a body of water amounting to 16,000,000,000 of cubic feet, enough to supply the ordinary outflow of Niagara for 20 hours. This amount is beyond that already accounted for by the recorded rise at Buffalo, which by itself would scarcely double the outflow even while it lasted. When we consider the pressure which must have existed in connection with the change of elevation of 4.7 feet in 13 miles between Ashtabula and Conneaut, and consider also the immense volume of water displaced west of them and not found to the eastward, it suggests the idea of an enormous eddy or swirl, more or less forcible, in that portion of the lake, the current setting down along the south shore and up along the Canadian side. The observations, though crude, seem to show conclusively that the surface of the lake is not level on the normal lines, but is much higher on the north shore. This is borne out by the fact before mentioned that during the height of the gale there is invariably a reflex current into the west point of the lake too strong to allow of the belief that it is caused by the gravity of the "piled up" water overcoming the force of the wind. It is a fact that most of the Lake Erie wrecks during a westerly gale are in the vicinity of the "Narrows." In an easterly gale, when these peculiar conditions do not exist, there is seldom a loss in that region.

Is it not possible that in these serious storms there are forces at work for destruction with which we are not familiar, and that a proper study would give the means for combatting them successfully?

I beg leave to suggest that the line of thought here touched upon is important enough to warrant further and more accurate study on the basis of definite data. If the conditions here suggested do actually exist, it will be of vast importance to the navigation interests to know of them; and in order to gain the information for a more thorough and accurate discussion, I respectfully recommend that steps be taken to have all light-keepers on Lake Erie record the height of water three times daily, together with the wind directions and velocities, and to have special instructions issued that they shall note any unusual conditions of weather or water. In any prolonged and severe storm, particularly those of April and October, they shall carefully note the extremes of water level and wind.

To be of any service in a further consideration of this subject, the Canadian authorities should be requested, through the proper channels, to cooperate fully.

I am thoroughly impressed with the idea that such observations will bear fruit of some importance at very slight expense.

Very respectfully,

WM. T. BLUNT,
Assistant Engineer.

Lieut. Col. JARED A. SMITH,
Corps of Engineers, U. S. A.

While the profile of extreme changes in this storm of October 14, 1893, lays no claim to exactness, the general agreement of data is such as to indicate conclusively that there are four distinct general steps in the resultant surface due to a westerly gale.

First. In the small shoal basin west of the islands.

Second. In the small bight immediately east of them.

Third. In the broad expanse of the lake.

Fourth. In the east basin, after the choking begins off Ashtabula and Conneaut.

The grades between these steps are somewhat abrupt at the islands and near Conneaut, and at these points dangerous currents must surely exist of unknown and varying directions and velocities.

Undoubtedly much the same conditions obtain in all westerly gales, though at present, with only one well-defined curve on record, the tracing of the ideal curves for other storms with the few actual observations as arguments seems hardly justified.

It is worthy of note that at Toledo, no matter from what level the fall starts nor how severe the gale, the limit of fall seems to be 7 to 7½ feet below mean level. I can learn of no instance when it fell below that limit, and yet it is known to have reached it no less than seven times since 1886 in storms of varying energy. The indications, based on

the recorded maxima at Buffalo, are quite conclusive, however, that in at least five other cases during that period this limit was reached at Toledo. The maxima of high waters have recently been quite fully recorded at Buffalo and at Erie, but at the west end of the lake the only continuous record is at Monroe, where the light keeper is not obliged to be on watch through the night, and therefore can not always follow the changes.

The greatest change, as well as the most extreme actual level reached at each end of the lake in westerly gales, occurred in the storm of January 10, 1889. At Buffalo the extreme actual level was 7.8 feet above mean level and the rise from the prevailing level was 8.2 feet. At Toledo the extreme actual level was 7.5 feet below mean level and the fall was 7.1 feet. This storm was of Texas origin and passed well to west and north of the lake, the gale reaching an extreme velocity of 82 miles per hour, with a maximum of 55 miles at Buffalo. This record shows a difference of level of 15.3 feet between the two ends of the lake. Several other occasions show differences of 12 to 14 feet.

As denoting the occasional rapidity of fall in a westerly gale, my journal shows that on October 15, 1886, the water at Toledo fell 3 feet in one hour. This was on the second day of a heavy gale, during which the water had already fallen 7 feet and returned during a lull in the storm.

Easterly storms.—The definite records of easterly storms are almost entirely confined to the extreme ends of the lake, and even then are not of great frequency. The observations recorded at other points are not sufficient to warrant any attempt at defining the particular changes of surface. The greatest change, as well as the most extreme actual level reached at each end of the lake in easterly gales, occurred in the storm of February 12, 1894. At Buffalo the extreme actual level was 6 feet below mean level and the fall from the prevailing level was 5.1 feet. At Toledo the extreme actual level was 7 feet above mean level and the rise was 7.9 feet. This storm was, like the westerly storm of January 10, 1889, of Texas origin, but passed across Ohio south and east of the lake, the gale reaching an extreme velocity of 88 miles per hour, with a maximum of 60 miles at Toledo. This record shows a difference of level of 13 feet between the two ends of the lake. Other easterly storms may have caused greater change, but unfortunately their records are not complete. For instance, on April 20, 1893, a rise at Toledo of 5.9 feet is recorded (5.4 feet above mean level), while at Buffalo we have no record of extreme. At other times we find the extreme record at Buffalo, but none at the west end of the lake.

A comparison of the two storms causing the largest effects in easterly and westerly gales shows that the maximum recorded fluctuation is at Buffalo, 13.8 feet (7.8 feet above to 6 feet below mean level); and at Toledo, 14.5 feet (7 feet above to 7.5 feet below mean level).

Occasionally a severe but short easterly gale precedes a continued westerly storm, causing a decided change in surface in both directions. On October 14, 1893, at Buffalo, with a short northeast gale, the water fell to 3.5 feet below mean level at 2 a. m. The wind shifted to southwest at 3 a. m., and the water reached a height of 4.6 feet above mean level at 10 a. m. The rise was thus 8.1 feet in eight hours. On November 25, 1895, at Buffalo, with a northeast gale, the water fell to 3.4 feet below mean level at 7 a. m. In a southwest gale on the 26th it rose to 5.6 feet above mean level at 11 a. m., then fell again to 3.1 feet below at 4 p. m. This gives a fall of 8.7 feet in five hours.

These large fluctuations of surface due to storm winds can not of

course be controlled, but a knowlege of their action and probable limits, including the currents induced by them, will be of large benefit in the consideration of any scheme for control of the general level of the lake. For their proper study data must be obtained in much more detail than that now available. At important points continuous records by self-registering gauges should be had for at least one year, reenforced by regular observations at each available point on both shores, carefully covering the extremes reached in all severe storms, the courses of currents, and in fact all phenomena incidental to surface changes or weather conditions.

The writer continues to be impressed by the thought, as expressed in the report of June, 1894, that dangerous currents of unknown direction and intensity accompany such severe storms as are outlined in the foregoing context, and if so, the fact will give additional interest and worth to the further investigation of the subject.

Preferably all gauges should be referred to a known horizontal plane; but as this necessitates extensive and accurate work at considerable expense, the yearly mean level at each point of observation will serve as a standard sufficiently accurate for practical purposes.

I am indebted for material assistance in collecting data used in this crude discussion to Lieut. Col. Jared A. Smith and Lieut. J. B. Cavanaugh, Corps of Engineers, United States Army, and to the various officers of the Weather Bureau along the Lake Erie shore, more especially Mr. E. A. Hanner, at Toledo.

WM. T. BLUNT,
United States Assistant Engineer.

TOLEDO, OHIO, *April 8, 1896.*

EXHIBIT B5.

WATER LEVELS FOR THE GREAT LAKES AND ST. LAWRENCE RIVER (PRIOR TO 1860).[1]

INTRODUCTION.

This presentation covers all obtainable information respecting the levels of the several Great Lakes prior to 1860. It comprises three deduced tables which give the results for three lakes, Michigan-Huron, Erie, and Ontario, so far as justified by the data and the study given the same up to this time; and a table of characteristic high and low waters from the earliest records to date, is included—and all are referred to the same planes of reference as used in recording the "Water levels for the Great Lakes and St. Lawrence River" for the period, 1860–1895.

The record proper is set forth in the accompanying tables, pages 00 to 00, inclusive. No attempt is made to present data respecting the St. Lawrence River and Lake Champlain, except as hereinafter noted. In making up this record great pains have been taken to obtain the same in each case and, when possible, as originally recorded, and this has involved much research and extended correspondence. In each case the plane of reference has been given where it could be deduced, so that the record can be referred to the standards now in use. Should subsequent information change any of the arbitraries, the record as thus presented enables the correction to be readily applied.

The presentation includes considerable matter not heretofore published, as the record made by Dr. I. A. Lapham at Milwaukee, the record of 1858 for Lake Erie at Cleveland by Whittlesey and Stannard, and the early record at Port Colborne, and the records at Port Dalhousie and at Kingston Mills for Lake Ontario. This is also the first attempt to present a complete collection of data in the original form, and to systematically refer the same to the planes now in use.

An endeavor has been made to follow all clues to a final determination. This has not been inconclusive in some cases, but in all such the results have been negative and of a character to indicate that the anticipated data did not exist. There yet remain possible sources of information which will take much time and labor to examine, and which have been beyond the available resources to attempt. The results are likely to be very meager, but in view of the value to be attached to all authentic information of this character, it seems desirable to completely exhaust the field of inquiry.

It has not been thought expedient at this time to attempt important conclusions. This should await the more exhaustive research and fuller compilation suggested above, and a careful study of all collateral evidence. It is believed that it will be found feasible to reproduce approx-

[1] Compiled from authentic sources, under the direction of L. E. Cooley, C. E., by Assistant J. E. Maloney, C. E., accompanied by seventeen tables.

imately, the significant features of the record for the greater part of the first half of the century, and to make the same substantially complete since the remarkable low-water period, including 1847, if not back to the high water of 1838.

SOURCES OF DATA.

The following notes give the direction in which inquiry has been made with negative results for the most part, and the probable avenues of further information if the same is in existence:

Lake Superior.—Mr. Lucius L. Hubbard, State geologist of Michigan, in letter dated November 5, 1896, refers to a report on water levels made by Mr. G. A. Marr, United States assistant engineer, and in reference to water levels prior to 1860, states: "In this office we have no records whatever that bear upon the question."

Maj. Clinton B. Sears, Corps of Engineers, United States Army, on November 9, 1896, forwarded the report of Mr. G. A. Marr referred to by Mr. L. L. Hubbard. There is nothing in the report referring to water levels prior to 1860. Mr. Marr, in letter to Maj. C. B. Sears, dated November 9, 1896, says: "I do not think we can give Mr. Cooley any additional information beyond what he already has."

Mr. E. S. Wheeler, United States assistant engineer at Sault Ste. Marie, in letter dated September 12, 1896, says: "I have your note of the 8th, inquiring if there are any water-gauge records at the canal earlier than 1860. I do not know of any. I feel quite confident that the State authorities never kept any, and I have never heard of any other."

A letter of inquiry in regard to water-level records prior to 1860 was addressed to the city engineer of Marquette, Mich., but no reply has been received to date. It is not likely that any record has been kept at this point.

In addition to the above, research has been made, and the reports and documents consulted are noted in table.

It is very doubtful if a further research of canal records will disclose additional data at Sault Ste Marie, and old Missions and Hudson Bay Company posts are the most available sources for further inquiry.

As to what may have been the condition in early times may be inferred from the following extract from report made by Mr. E. S. Wheeler, United States assistant engineer, dated Detroit, January 2, 1884 (Report of Chief of Engineers, 1884, Part III, p. 2015):

> The channel connecting Portage Lake with Torch Lake, or Lake Linden, as it is now called, shows some indications that the surface of Lake Superior has been 4 or 5 feet lower than at present. * * *
>
> Assistant Engineer Burns mentions the channels in Superior Bay and Lake George as a possible confirmation of the low-water theory. * * * It is not likely that the maximum or minimum has occurred during this time (1870 to 1884). It is quite improbable that the lowest stage has occurred since 1870. The Lake Linden outlet indicates that quite recently there has been a stage at least 3 feet lower than the lowest observed stage (1870 to 1884). The negative proof is much stronger that for at least a century the lowest stage has not been much more than 3 feet lower than the lowest known stage.

In a letter dated December 15, 1896, Mr. E. S. Wheeler speaks of the above-mentioned report, and adds:

> Since then I have had some opportunity of watching the ice effects. In very cold winters the ice sometimes freezes to a depth of 3 feet. This would force the water running under it into a much narrower space, and might possibly cause the excavation of the deep channels mentioned. The natural channels in Lake George seem to have been formed under conditions different from any that have yet been observed. A low-water period would be a sufficient explanation. So also would very thick ice. The two conditions might occur simultaneously. Indeed, they would be likely to, for a long, cold winter causes low water until the snow and ice begin to melt.

It seems to me quite probable that there have been within geologically recent times periods when the water in the Great Lakes has been several feet lower than the lowest observed stage.

Lake Michigan-Huron.—Capt. George A. Zinn, Corps of Engineers, United States Army, in letter dated September 23, 1896, states: "In reply to your letter of the 22d inst., asking if there are any gauge records at the lower lock on the Fox River improvement opening into Green Bay, taken between 1849 and 1854, I have to inform you that there are no records in this office of any such gauge being kept for the time mentioned."

Mr. G. H. Benzenberg, city engineer of Milwaukee, in response to an inquiry for records prior to 1860, furnished a partial profile of water level from 1836, taken from the records of the late Dr. I. A. Lapham.

Mr. I. S. Bradley, librarian of the State Historical Society of Wisconsin, in letter dated October 1, 1896, states: "We have made a very thorough search for material on the subject in this library, and, am sorry to say, have not been successful."

Mr. N. S. Boynton, mayor of Port Huron, Mich., states: "I do not know of any records, and can not find that any of our residents, even among the sailing fraternity, have kept a record relative to water levels prior to 1854. I have made inquiries of persons who might possibly keep track of matters of that kind, but can not gather anything which would be at all reliable."

Inquiries for records of the Illinois and Michigan Canal, supposed to have been kept at the Bridgeport lock, were not successful. The following statements are noted:

Mr. Horace M. Singer, superintendent of repairs for several years after the canal was opened, called at the office of the Commission and stated that he had no knowledge of any records being kept. He believes that there are none.

Mr. Wm. Thomas, formerly superintendent of canals, referred to Mr. Butler, of Lockport, formerly clerk to the collector at Bridgeport.

Mr. C. L. Harrison, C. E., in letter of November 2, 1896, states: "I have seen Mr. Butler and he informs me that he did not keep any record of the water levels;" also, "there seems to be no information on this subject in the canal office."

Mr. Wm. Milne, formerly clerk of the canal board, in letter of October 17, 1896, says: "I have no distinct recollection of any record such as you desire. Think possibly among the papers returned from the Bridgeport office to the general office at Lockport some data might be found."

The records of the canal office at Lockport have been examined by Mr. C. L. Harrison, C. E., but without result as noted in his letter.

A letter dated November 5, 1896, from Mr. Frank B. Desnoyers, mayor of Green Bay City, indicates the existence of some data, and that he will forward it as soon as it is compiled. (This has not been received.)

The record kept at Milwaukee by the late Dr. I. A. Lapham, which has not been published heretofore, was obtained through the courtesy of Miss Julia Lapham.

It is possible that further research among the archives of the Fox River Improvement and the Illinois and Michigan Canal, and the notes of early surveys for these projects, may disclose data of importance, and in this connection it may be worth while to consult early mission records at Mackinac and other points, otherwise there is little probability of information except of a very general character.

Lake Erie.—Inquiries were addressed to Mr. Edward B. Guthrie, chief engineer, city of Buffalo; Mr. M. E. Rawson, chief engineer, city of Cleveland, and Mr. J. L. Little, division engineer, New York State canals, and the answers show that no records prior to 1860 are in any of these offices. Mr. Little in his letter notes the destruction by fire of the records in the canal office at Rochester, N. Y.

A letter addressed to Prof. G. Frederick Wright, Oberlin, Ohio, was referred by him to Mr. Peter Neff, secretary of the Western Reserve Historical Society, Cleveland, Ohio, and through the efforts of Mr. William T. Blunt, United States assistant engineer, and Mr. Neff some unpublished data were obtained from the original manuscript of Charles Whittlesey now in the possession of the society.

A letter of inquiry sent to the department of railways and canals, Canada, in reference to a record at Port Colborne, met with a favorable response, and the data at that point from 1849 down were promised. (This has not been received.)

It is presumed that the record for 1859 as kept at Cleveland will be found, and it may be that further search among the early notes of the Welland and Erie canals will discover important data at Port Maitland, Port Colborne, and at Buffalo or Black Rock; otherwise, further information other than of a general character is not to be anticipated.

Lake Ontario.—A letter to Col. A. T. Smith, Thirteenth Infantry, United States Army, at Fort Niagara, N. Y., in reference to gauge records at the mouth of the Niagara River, was referred to Maj. W. S. Stanton, Corps of Engineers, United States Army, and made the subject of special inquiry by Mr. William Pierson Judson, United States Army, assistant engineer. An examination of the records of Fort Niagara fails to show any records not at present in the hands of the Commission. A reference is noted by Mr. Judson, as follows: "Under date of January 14, 1843, is the following passage in a letter to the Chief of Engineers: 'The top of the sill is 1 foot 8 inches above the level of the highest water ever known, and about 5 feet 8 inches above the present surface.'"

Mr. Hugh V. Payne, superintendent meteorological office, Toronto, Canada, states in letter of August 18, 1896: "I find we have no records of the lake levels here, either in this office or at the harbor master's office. I believe there are none in existence." Mr. Payne refers to department of public works, and of railways and canals, as possible sources of data.

Records were obtained from Mr. Thomas Monro, engineer Soulanges Canal, and from the department of railways and canals, and are noted in list of data furnished.

The secretary of the department of railways and canals, Canada, at Ottawa, notes the destruction by fire of the office records of the Rideau Canal at Kingston Mills, other than those furnished.

To Prof. G. Frederick Wright, Oberlin, Ohio, the Commission is indebted for references to many of the documents consulted.

The following notes are taken from an article on Levels of Lake Ontario, by Edward Giddings, published in pamphlet at Lockport, N. Y., in 1838. Abstracts made at New York State Library by courtesy of the secretary and director, Mr. Melvil Dewey.

From 1815 to 1821 my observations were not made with a regularity, frequency, or precision to insure exactness as to the yearly rise and fall of the lake waters; and as set down in the annexed table they may, therefore, occasionally vary in a small degree from correctness; but from the attention I gave the subject, and the pains I took to make the table a near approximation to fact, I am confident the errors in no

cases exceed 3 inches. From 1821 to 1827 my observations were made monthly, as near the first of each month as a settled state of the lakes would admit, for a high wind of long continuance, blowing lengthwise the lake, will, near the Niagara, sometimes make a difference of nearly a foot above or below the mean level, as the wind happens to favor an accumulation or recession of the waters. These observations were recorded with minute exactness; and, besides these, I took intermediate measurements whenever the change of level made it necessary, so that the maxima and minima for these years, as recorded in the table, may be depended upon as scrupulously exact. The table does not contain the monthly fluctuations, nor is it necessary; they are exceedingly small, and, compared with the yearly, are like the small waves that ride upon the heavy swells of the ocean. The principal flood, as will be seen by the table, attains its maximum in June or July.

From October, 1827, to August, 1838, a period of nearly eleven years, I took no measurements and made no observations whatever, as my removal from the lake rendered it inconvenient for me to attend longer to a subject in which, however, I took no little interest, and which I was in hopes of continuing without interruption.

On the 28th of August, 1838, I again took a measurement, and ascertained from it, in connection with the concurrent testimony of the neighboring residents and the water marks upon objects on the margin of the river, both the time and the quantity of the maximum for the present year, which may be found recorded in the table. The maximum or extreme ebb may be found this fall or winter, and from the extraordinary scarcity of rain during the past four months, in connection with the unexampled degree of heat, we may anticipate a fall of 3 feet at least; not so much, however, from excessive evaporation, although that has its share of influence, as from the absence of rain and consequent draining of the streams which feed the lake tributaries and the lake itself.

I have been unable to learn anything definite respecting the fluctuations of the lake between 1827 and 1838, but from all the information I can gather on the subject worthy of credit, am of the opinion that from 1828 to 1834, both inclusive, they did not materially differ from those of the preceding seven years; but since 1834 the floods have invariably exceeded the ebbs, a consequent yearly rise of the waters has ensued, until the present summer has found them higher than they have before been known for fifty years, according to the testimony of an old and respectable gentleman who has resided during that period on the lake border. The highest floods, during the period of my residence at the lake, were those of 1815 and 1817, but by the table it will be seen that of 1838 far exceeded either of them, being 22 inches above that of 1815 and 25 above that of 1817. I also learn that the floods reached their maxima about midsummer, as was almost invariably the case during the years of my observations.

There are some other facts connected with this subject which ought not, perhaps, to be passed entirely unnoticed. The yearly rise of water is almost invariably more rapid than the fall. When the yearly floods attain their height they do not remain stationary there, but commence ebbing immediately. Not so with the ebbs, they are often stationary for months.

The causes of the lake fluctuations are too manifest to raise a shadow of doubt. They are the ascent and descent of water evaporation, rain, and snow; but the proportion of influence exerted by each of these is the true question at issue, and must remain undecided, or at least involved in more or less doubt, until meteorology is better understood than it is at present.

Mr. Giddings's record is compiled among the appended records for Lake Ontario.

Mr. Thomas Monro, in letter of October 28, 1896, gives the following information regarding the low water on Lake Ontario:

In October–November, 1867, in connection with the projected Murray Canal, I made some inquiries and took measurements having for their object the determination of lowest water of Lake Ontario. Satisfactory information was obtained as to the level of the water during the year 1848, at which period it was said to have been lower than it ever has been since. This was found to be 1 foot 6 inches lower than the water in October–November last (1867), highest water mark being 3 feet over the level at that time, thus showing the difference between these extremes to have been 4 feet 6 inches.

But it was stated by several of the oldest residents that a lower level even than this had occurred about the year 1818–1820, when certain shoals (which had in October last about 2 feet of water on them) were said to have been dry. Thus the lowest water level at the above period seems to have been 6 inches lower than it was in 1848, and appears to establish the greatest fluctuation at 5 feet, as above stated. This extreme variation is corroborated by the record kept at Port Dalhousie and Oswego.

You will see that the above is very indefinite and hangs on the point as to how much the shoals were dry. Translated into our levels, the low water of 1819 was 249.09 — (3.42 + 1.50) = 244.17 feet.

This agrees with the low water of 1819, as given by Mr. Judson (see record), who has given the elevation at 244.21 feet. This is probably the level during the fall of the year, and is not inconsistent with Mr. Giddings's record of maximum and minimum for the year.

The most probable sources of future inquiry will be among the early papers and notes of the Welland Canal, the Oswego branch of the Erie Canal, and the Rideau Canal. Papers may still be in existence which would reward a research, and it may be that other points around Lake Ontario would develop some additional data. This lake suggests more probability of further data being found than any other.

Lake Champlain.—The inquiries made and the data available have been fully noted in "Water levels of the Great Lakes, etc., 1860–1895."

As noted the additional sources of information are very doubtful, being confined to the possibility of unknown records in connection with the canals at Whitehall and St. Johns. It has been suggested that the marks of characteristic waters made at Shelburne Bay since 1826, by the Champlain Transportation Company, should be leveled up while the same can be identified.

St. Lawrence River.—A record at Ogdensburg from 1850 to 1857 is available and is noted in Lake Ontario records appended.

On the canals of the St. Lawrence River, a record has been kept since 1849, the highest and lowest of each month being published in the annual reports of the minister of public works of the department of railways and canals, Canada.

An inquiry was sent to Mr. John Kennedy, chief engineer, harbor commissioners of Montreal, in regard to records previous to 1850; Mr. Kennedy in his reply states: "I regret I can not give you any information respecting low water previous to 1850; in fact, we have no records whatever beyond those already sent you." The record at Montreal from 1850 to 1895 is published as Table No. 14 in "Tables of water levels for the Great Lakes, etc., 1860 to 1895."

The St. Lawrence offers little probability of further data, as the canal system was not undertaken until sometime in the forties, the only sources being the very minor works undertaken in an early day above Montreal at the two ends of Lake St. Louis.

Ottawa River.—A record has been kept at the entrance lock of the Rideau Canal at Ottawa, and the observations on the 1st and 15th of each month published in the annual report of the minister of public works and the department of railways and canals, Canada. This record begins in 1850.

DATA FURNISHED AND DOCUMENTS CONSULTED.

The references and data specially furnished and which constitute the record are given succinctly in the compilation below:

Smithsonian Contributions to Knowledge, vol. 12, 1860; article by Charles Whittlesey.

Fugitive Essays, by Charles Whittlesey.

Miscellaneous Papers, by Charles Whittlesey.

History of Cleveland, by Charles Whittlesey.

Foster and Whitney's Report on Geology of Land District of Wisconsin; article by Charles Whittlesey.

Biography of Charles Whittlesey.

Abstract of original manuscript of Charles Whittlesey with diagrams, by Mr. William T. Blunt, United States assistant engineer, through the courtesy of Mr.

Peter Neff, secretary and librarian, Western Reserve Historial Society, Cleveland, Ohio.

Trip to Lake Superior, by Professor Agassiz.

Geological Survey of Canada, 1849–1852, by Alex Murray.

Geological Survey of Ohio and Michigan.

Geological Survey of Wisconsin, Minnesota, and Iowa, 1852, by D. D. Owen.

Report on Meteorology, New York, by F. B. Hough (1850–1863); from the New York State Library, by courtesy of Mr. Melvil Dewey, secretary and director.

American Association for Advancement of Science; Proceedings, 1873, 1875, 1886, and vol. 37.

American Journal of Science, vols. 16, 20, 27, 56, 57, 69, 70, 77, 140, and 141.

Hunt's Merchant Magazine, vols. 8 and 28.

Annals of Science, vol. 1.

Transactions and Proceedings of Royal Society of Canada, vol. 7.

Canadian Journal of Science and Arts, vol. 1.

Littell's Living Age, vol. 35.

Science, vol. 7.

House and Senate documents, Thirty-second and Thirty-seventh Congresses, examined by index.

Copy of Report of Chief of Engineers, United States Army, for 1860, by courtesy of Mr. D. Parrand Henry, C. E.

Reports of the Chief of Engineers, United States Army.

Joint Documents of the Michigan Assembly, 1855–1860.

Record of the Detroit Waterworks Engineers, by courtesy of Mr. G. Y. Wisner, C. E.

Copy of original notes of the late Dr. I. A. Lapham, by courtesy of Miss Julia Lapham.

Welland Canal Data, from private papers of Mr. Thomas Monro, engineer Soulanges Canal.

Record at Kingston Mills, Rideau Canal, from the department of railways and canals, Canada.

Record at Oswego, by J. W. Judson, C. E., by courtesy of Mr. William Pierson Judson, C. E.

Record at Milwaukee, by courtesy of Mr. G. H. Benzenberg, city engineer.

Pamphlet published by Edw. Giddings, at Lockport, N, Y., 1838, original in New York State Library; abstracts furnished by Mr. Melvil Dewey, secretary and director.

Documentary History of the Erie and Champlain Canal, 1808 to 1829.

Records of the Illinois and Michigan Canal, at Lockport, Ill., examined by Mr. C. L. Harrison, C. E.

Reports of department of public works, Chicago.

Penny Magazine, vol. 6.

American Naturalist, vols. 4 and 20.

United States Service Magazine, vol. 2.

Christian Examiner, vol. 49.

Forum, vol. 5.

Magazine Western History, vol. 3.

Old Documents of Chicago.

Biography of Governor Clinton.

Biography of Giddings Family.

Anti-Masonic Almanac, 1838, by Edward Giddings (New York State Library).

DEDUCED TABLES OF WATER LEVELS.

The three tables herewith give the results for Lakes Michigan-Huron, Erie, and Ontario, so far as justified by the data and the study thereof up to this time. The water levels are referred to the same planes as used for the records, 1860–1895.

LAKE MICHIGAN.

(Deduced table).

[Readings are below high water of 1838, or the Lake Survey plane of reference. Elevation = 584.34 feet.]

Year.	Jan	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Mean.
1810	.....	a6.67	.....	.....	.....	b4.67	.....	.....	.....	.....	.....	.....	.....
1820	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
1821	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
1822	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
1823	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
1824	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
1825	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
1826	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
1827	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
1828	.....	.....	.....	.....	.....	b1.84	1.78	1.84	.....	.....	.....	.....	.....
1829	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
1830	.....	.....	.....	.....	.....	b1.84	.....	.....	.....	.....	.....	.....	.....
1831	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
1832	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
1833	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
1834	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
1835	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
1836	.....	.....	4.00	.....	.....	b1.00	.....	.....	.....	.....	.....	.....	.....
1837	.....	.....	.....	.....	3.20	b0.59	.....	.....	.....	.....	.....	.....	.....
1838	.....	.....	.....	.....	.....	(0.00)	0.00	.....	.....	.....	.....	.....	.....
1839	.....	.....	.....	.....	.....	.....	b1.33	.....	.....	.....	.....	b3.67	.....
1840	b4.50	.....	.....	b3.07	b2.96	b2.88	b2.62	(2.88)	b3.23	b3.38	b3.56	b3.79	.....
1841	b3.71	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	4.43	.....
1842	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
1843	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
1844	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
1845	.....	.....	.....	.....	.....	3.50	.....	.....	.....	.....	.....	.....	.....
1846	(4.40)	4.42	4.27	3.79	3.43	3.44	(3.38)	3.65	4.13	4.38	4.66	5.03	4.08
1847	5.38	5.50	5.28	5.19	4.98	4.57	4.51	4.56	4.45	4.77	4.88	5.09	4.93
1848	5.29	5.34	c5.35	5.00	5.30	5.05	4.47	4.46	4.64	4.72	4.82	4.77	4.93
1849	4.80	4.70	4.90	(4.70)	(4.60)	(4.05)	3.75	3.75	.....	.....	.....	.....	.....
1850	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
1851	.....	.....	.....	.....	.....	.....	2.57	2.30	.....	.....	b2.43	.....	.....
1852	.....	.....	.....	.....	.....	.....	.....	1.50	2.02	2.10	1.96	.....	.....
1853	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
1854	.....	.....	.....	3.70	3.05	(2.78)	(2.46)	(2.50)	2.61	3.18	3.45	3.53	.....
1855	3.79	(3.82)	3.75	3.67	3.10	2.77	2.68	2.57	2.48	2.61	2.81	2.71	3.06
1856	2.65	3.14	3.13	2.99	2.56	2.63	2.56	2.75	2.87	3.06	3 12	3.35	2.90
1857	3.55	3.27	(3.14)	2.68	2.33	2.03	1.60	1.41	1.56	1.49	2.30	2.26	2.30
1858	2.33	2.62	2.70	2.18	1.70	1.28	0.89	0.93	1.33	1.48	(1.81)	1.79	1.75
1859	2.28	2.15	2.09	1.45	1.30	1.30	0.65	0.95	1.19	1.52	2.02	1.95	1.57

a From Michigan Geological Report.

b From article by Charles Whittlesey; Michigan Geological Report, 1839, and table by Mr. A. W. Higgins.

c March 6, 1848, lowest water, 5.65 feet.

REMARKS.—1800 to 1802 very high; 1814 and 1815, unusually high; from article by Charles Whittlesey. Dr. I. A. Lapham makes the following statement: "Milwaukee zero (March, 1836) is about 3 feet above low water of 1819-20." Maj. R. Lachlan gives 1819 as 6 feet below 1838; Mr. A. W. Higgins gives 1819 as 5.25 feet below 1838, but this is not stated as lowest water. Tables giving maximum and minimum readings for any year have been used by putting the maximum in July and the minimum in December or January. July and August, 1828, from observations by Governor Cass at Green Bay; 1836 to May, 1854, inclusive, with the exception of those marked *b*, readings from Dr. I. A. Lapham's original record; September, 1854, to December, 1855, inclusive, from Col. J. D. Graham's original record; 1856 to 1859, inclusive, from record by Mr. W. D. Clark, assistant engineer, board of public works, Chicago. Inserted (2.88) for August, 1840, as approximately correct.

Interpolations are indicated by parentheses and are obtained as follows: January, 1846: From the mean of February, 1847-1849, take February, 1846, and subtract this difference from the mean for January, 1847-1849. July, 1846: From the mean for June and August, 1847-1848, take mean of June and August, 1846, and subtract difference from mean for July, 1847-1848. April, May, and June, 1849: From the monthly means for five months of 1846-1848 take corresponding readings for 1849 and apply the average difference to monthly means for April-June. February, 1855, and March, 1857: From the mean of months on either side for other years take reading on either side for same year and apply the average difference to the mean of the same months for other years. June, July, and August, 1854: From the mean of months on either side for the years 1855-1859 take reading on either side for same year and apply the average difference to the mean of the same months for the years 1855-1859. November, 1858: Original reading assumed to be in error and replaced by one interpolated from the months on either side.

LAKE ERIE.

(Deduced table.)

[Readings are below high water of 1838, or the Lake Survey plane of reference. Elevation = 575.20 feet.]

Year.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Mean.
1819	.....	.....	.....	.....	.....	a5.33	.....	a5.75	.....	.....	.....	.....	.....
1820	.....	.....	.....	.....	.....	.....	.....	5.04	.....	.....	.....	.....	.....
1821	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
1822	.....	.....	.....	.....	.....	(5.00)	.....	.....	.....	.....	.....	.....	.....
1823	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
1824	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
1825	.....	.....	.....	.....	.....	(4.00)	.....	.....	.....	.....	.....	.....	.....
1826	.....	.....	.....	.....	.....	(2.83)	.....	.....	.....	.....	.....	.....	.....
1827	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
1828	.....	.....	.....	.....	.....	4.04	.....	3.39	.....	.....	.....	.....	.....
1829	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
1830	.....	.....	.....	.....	.....	.....	.....	3.39	.....	.....	.....	.....	.....
1831	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
1832	.....	.....	.....	.....	.....	(2.83)	.....	.....	.....	.....	.....	.....	.....
1833	.....	.....	.....	.....	.....	(3.17)	.....	.....	.....	.....	.....	.....	.....
1834	.....	.....	.....	.....	.....	2.52	.....	.....	.....	.....	.....	.....	.....
1835	.....	.....	.....	.....	.....	2.77	.....	.....	3.27	.....	.....	.....	.....
1836	.....	.....	.....	.....	.....	.....	.....	2.89	.....	.....	.....	.....	.....
1837	3.10	.....	.....	.....	.....	2.58	.....	1.89	3.50	.....	.....	.....	.....
1838	.....	.....	.....	.....	1.00	b0.33	0.25	0.81	1.22	1.61	.....	1.96	.....
1839	3.60	.....	.....	.....	1.84	1.51	1.26	1.21	2.01	1.04	.....	.....	.....
1840	.....	.....	.....	.....	1.01	0.44	1.01	0.94	2.04	2.24	.....	.....	.....
1841	.....	.....	2.75	.....	1.84	2.10	2.54	3.04	3.59	4.47	.....	.....	.....
1842	2.35	.....	.....	2.50	1.84	.....	.....	.....	.....	.....	.....	.....	.....
1843	.....	.....	.....	.....	2.38	.....	.....	.....	.....	.....	.....	.....	.....
1844	.....	.....	.....	.....	2.13	.....	.....	.....	.....	.....	.....	.....	.....
1845	.....	.....	.....	.....	2.04	.....	.....	2.63	2.95	3.18	3.47	3.80	.....
1846	4.05	4.39	4.47	4.10	3.13	2.84	2.89	3.06	.....	.....	.....	.....	.....
1847	.....	.....	.....	.....	2.54	.....	.....	.....	.....	2.84	.....	.....	.....
1848	.....	.....	.....	.....	2.88	.....	.....	.....	.....	2.40	.....	.....	.....
1849	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
1850	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
1851	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
1852	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
1853	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
1854	.....	.....	.....	.....	.....	.....	.....	1.94	2.27	2.41	2.11	2.60	.....
1855	2.72	3.03	2.97	2.68	2.16	1.81	1.38	1.16	1.81	1.57	1.50	1.22	2.01
1856	1.86	2.26	2.59	2.10	2.14	1.76	1.73	1.88	2.13	2.79	2.91	2.62	2.23
1857	3.37	3.34	.....	.....	1.61	1.23	1.14	1.18	1.43	1.80	1.35	1.35	.....
1858	1.26	1.66	1.63	1.52	1.26	—0.10	—0.05	0.04	0.60	0.70	1.12	1.02	0.89
1859	1.03	1.25	0.84	0.27	0.39	0.42	0.36	0.66	1.26	1.05	1.23	1.43	0.85

a Buffalo Commercial Advertiser: 1838 was 5.33 feet above 1819 in June, and 5 75 feet in August; according to Dr. Houghton it might be 6 feet. Mr. A. W. Higgins gives 1838 as 5.25 feet above 1819.

b June 25 the reading was 0.00 (C. Whittlesey).

REMARKS.—Maj. R. Lachlan: 1815 and 1816, 2 feet below 1838; 1817 and 1818, falling. Charles Whittlesey: 1822, 5 feet below 1838; 1825, 4 feet below 1838; 1826, 2.83 feet below 1838; 1832, 2.83 feet below 1838; 1833, 3.17 feet below 1838. General level 1830, same as 1828, Maj. R. Lachlan.

General notes.—1788 to 1815, no records, but reports from old settlers (from Charles Whittlesey's table). From table by Maj. R. Lachlan: 1790, 5.50 feet above 1819; 1795–96, described as low; 1800–1802, high; 1806, low; 1810–11, 6 feet below 1838.

The readings in this table are taken from the original records by Whittlesey at Cleveland, Commercial Advertiser at Black Rock, and J. Lathrop, C. E., at Black Rock. The deduced tables of Messrs. Whittlesey and Lachlan were used when no original data was at hand. From 1854 to 1859 is taken from table in report of Chief of Engineers, 1876, and in appended tables. Part of 1857 and all of 1858 are covered by observations by Charles Whittlesey, at Cleveland.

LAKE ONTARIO.

(Deduced table.)

[Readings are above the zero of United States Engineer's gauge at Oswego, N. Y. Elevation = 244.21 feet.]

Year.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Mean.
1815	.....	.....	0.23	.....	.....	.....	2.89	.....	.....	.....	.....	.....	.....
1816	.....	.....	0.00	.....	.....	.....	1.73	.....	.....	.....	.....	.....	.....
1817	.....	.....	0.73	.....	.....	2.64	.....	.....	.....	.....	.....	.....	.....
1818	.....	.....	.....	0.23	.....	2.06	.....	.....	.....	.....	.....	.....	.....
1819	.....	.....	—0.09	.....	.....	1.73	.....	.....	.....	.....	.....	.....	.....
1820	.....	.....	—1.19	.....	.....	.....	0.73	.....	.....	.....	.....	.....	.....
1821	.....	.....	.....	—0.77	.....	.....	2.39	.....	.....	.....	.....	.....	.....
1822	.....	.....	—0.52	.....	.....	1.73	.....	.....	.....	.....	.....	.....	.....
1823	.....	.....	—0.44	.....	.....	2.06	.....	.....	.....	.....	.....	.....	.....
1824	.....	.....	—0.27	.....	.....	.....	2.23	.....	.....	.....	.....	.....	.....
1825	.....	.....	—1.77	.....	.....	0.48	.....	.....	.....	.....	.....	.....	.....
1826	.....	.....	—1.77	.....	.....	.....	0.73	.....	.....	.....	.....	.....	.....
1827	.....	.....	.....	.....	.....	2.39	.....	.....	.....	1.73	.....	.....	.....
1837	3.33	(2.42)	(2.59)	(2.95)	(3.53)	(3.98)	3.16	(3.62)	(3.12)	2.67	(2.56)	(2.45)	3.03
1838	(2.91)	(2.86)	(3.03)	(3.39)	(3.97)	(4.42)	4.75	3.64	3.77	3.06	(3.00)	(2.89)	3.47
1839	2.50	(2.10)	(2.27)	(2.63)	(3.21)	(3.66)	3.33	3.41	2.92	2.38	2.00	(2.13)	2.71
1840	(2.09)	1.50	2.08	2.58	3.29	3.75	3.58	3.33	2.80	(2.49)	2.26	2.07	2.66
1841	2.06	1.96	1.75	2.00	3.21	3.33	3.04	2.63	(2.16)	1.50	0.78	0.66	2.00
1842	1.00	1.29	1.67	1.86	(2.23)	2.00	2.50	2.17	2.00	1.65	1.40	1.08	1.74
1843	1.30	(1.18)	1.65	1.17	2.25	2.83	2.67	2.19	1.71	1.63	1.54	1.17	1.77
1844	1.16	1.17	1.37	1.67	2.50	2.50	2.52	2.58	1.25	1.29	(1.20)	0.83	1.67
1845	1.15	1.38	1.67	2.67	2.67	2.66	2.33	1.87	1.67	1.33	0.96	(1.22)	1.80
1846	0.75	0.50	1.00	1.25	1.50	1.75	1.75	1.50	1.25	1.25	1.00	1.25	1.23
1847	1.00	1.50	2.00	2.00	2.58	2.92	2.92	2.92	2.00	1.75	1.42	1.17	2.01
1848	2.58	2.17	1.42	1.83	1.83	1.92	1.83	1.75	1.33	0.92	0.50	0.58	1.56
1849	1.65	1.61	1.81	2.17	2.79	2.83	1.77	1.36	1.06	0.69	0.65	0.55	1.58
1850	0.78	0.90	1.22	1.54	2.02	2.22	1.90	1.46	1.29	0.91	0.51	0.57	1.28
1851	0.60	0.76	1.25	1.80	2.12	2.24	2.12	1.91	1.79	1.28	1.16	1.08	1.51
1852	1.07	1.12	1.46	2.00	2.89	3.38	3.28	2.89	2.49	2.27	2.22	2.22	2.27
1853	2.32	2.40	2.41	2.61	3.29	4.25	3.75	2.82	2.55	2.24	2.16	2.14	2.75
1854	2.01	1.77	1.84	2.22	2.91	3.25	3.31	3.13	2.68	2.01	1.31	0.61	2.25
1855	0.62	0.47	0.62	0.43	1.06	2.24	2.36	2.22	2.48	1.95	1.26	1.22	1.41
1856	0.83	0.32	0.82	1.54	2.31	3.19	3.34	2.90	1.08	1.41	0.90	0.20	1.57
1857	0.24	0.54	1.01	1.55	2.43	3.39	3.50	3.91	3.62	3.25	3.21	3.51	2.51
1858	3.54	3.41	3.31	3.57	4.47	4.75	4.01	4.61	4.20	3.95	3.85	3.82	4.01
1859	3.79	3.66	3.35	4.01	4.42	4.71	4.78	4.62	4.17	3.57	2.99	2.57	3.89

REMARKS.—"1795, yearly change of level 3 feet, the lake reported to be higher than for the past thirty years." The following data are used in deducing the table: 1815 to 1827, from record kept by Edward Giddings, at mouth of Niagara River; 1837 to 1845, from record kept by J. W. Judson at Oswego, and a record by Mr. Ousten at Gull Island, and a few readings from a deduced table by Charles Whittlesey; 1846 to 1848, from record kept by regents of New York University at mouth of Genesee River; 1849 to 1859, from record kept at Port Dalhousie.

Interpolated monthly means are indicated by parentheses, and are found for any year by taking the mean of the monthly mean for each month for the fourteen years, 1846 to 1859, and correcting the same by the average difference between the observed monthly means for that year and the corresponding mean of the monthly mean in the fourteen-year series. Records previous to 1849 depend upon single observations.

CHARACTERISTIC HIGH AND LOW WATERS.

The following table gives the characteristic high and low waters, so far as they can be assigned, from the earliest records down to the present time. These may be accepted provisionally as an indication of the nature of the conclusions from the record.

Characteristic high and low waters—1815 to 1895.

HIGH WATERS.

Year.	Lake Michigan (below high water of 1838).	Detroit River (below high water of 1838).	Lake Erie (below high water of 1838).	Lake Ontario (above zero of Oswego gauge).
1814 and 1815	Unusually high	Unusually high		July, 1815 2.89
1838	July 0.00	Summer 0.00	June 0.00	July 4.75
		Aug 0.49		Sept 3.77
1853		July 1.07		June 4.25
1858	Nov 0.69	June 0.15	June 19 −0.25	June 4.75
1859	July 0.65	July 0.65	Apr 0.27	July 4.78
1862	June 1.67		June 0.69	May 4.76
1870	Sept 2.12	July 1.29	July 1.35	May 4.83
1876	July 1.20	July 0.57	June 0.59	July 4.23
1886	June 1.16		June 1.20	May 4.52

LOW WATERS.

			1810 and 1811, general. 6.00	Mar., 1816 0.06
1819	Feb 6.67	Mar 6.67	June 5.33	Mar −0.69
	June 4.67	June 5.82	Aug 5.75	June 1.73
1820	About same as 1819	About same as 1819	Aug 5.04	Mar −1.19
1825			General level. 4.00	Mar −1.77
1841	Dec 4.43	Oct 6.15	Oct 4.47	Dec 0.66
1846	Dec 5.03		Mar 4.47	Mar a 0.00
1847	Feb 5.50		Mar (3.88)	Jan 1.00
1848	Mar. 6 5.65		Mar (4.22)	Nov a 0.00
1857	Jan 3.55	Jan 3.32	Jan 3.37	Jan 0.24
1866	Feb 4.46		Feb 3.49	Jan 1.34
1868	Dec 4.34	Feb 3.96	Feb 4.07	Jan 0.39
1869	Mar 4.63	Jan 3.67	Feb 3.53	Jan 1.10
1873	Jan 4.82	Jan 3.66	Jan 3.95	Jan 0.19
1881	Jan 3.76	Jan 3.51	Jan 3.50	Feb 0.61
1891	Dec 4.99		Nov 3.90	Dec 0.29
1892	Jan 4.87		Feb 4.01	Feb 0.36
1895	Dec 5.75		Nov 4.41	Nov −0.71

a From the original record of Mr. J. W. Judson, C. E., March, 1847 and 1848, for Lake Erie are approximate.

REMARKS.—*High waters:* 1790, Lake Erie = 5.50 feet above 1819. The high water of 1838, referred to as a plane of reference, is the plane adopted by the Lake Survey. *Low waters:* 1822, Lake Erie, 5 feet below high water of 1838; 1826, Lake Ontario in March = −1.77 feet.

THE RECORD.

The record is appended, and is compiled separately for each lake and river, and exhibits all the information obtainable except in regard to the St. Lawrence and Lake Champlain. The list is as follows: Lake Superior, 2 sheets; Lake Michigan-Huron, 4 sheets; Detroit River, 1 sheet; Lake Erie, 5 sheets; Lake Ontario, 5 sheets.

No diagram has been drawn to exhibit the graphical record, as it has been thought wise to defer this until the final digest has been made.

The authority for the information is set forth in connection with the several collections of data.

Very respectfully submitted, J. E. MALONEY.

WATER LEVELS PRIOR TO 1860 FOR THE GREAT LAKES.

LAKE SUPERIOR.

[Plane of reference is the miter sill, head of canal, Sault Ste. Marie. (Article by Charles Whittlesey, Smithsonian Contributions to Knowledge, Vol. XII, 1860.)]

Year.	Jan.	Feb.	Mar.	Apr.	May.	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Locality.	Observer.
1827-28*a*	.....	.....	....	.....	.....	.....	.....	...	.....	.....	.....	.....	S.Ste.Marie.	Capt. Dearborn,U.S.A.
1838*b*	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....do	Maj. R. Lachlan.
1844-45*c*	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....do	
1846*d*	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	Copper Harbor.	W. W. Mather.
1847*e*	.....	.....	10.00	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....do	Turrill and Mather.
1851*f*	.....	.....	.....	.....	.....	.....	.....	...	12.25	.....	.....	.....	.....do	D. D. Brockway.
1852*f*	.....	.....	.....	.....	.....	.....	11.58	.....	.....	.....	.....	.....	.....do	Mr. Turrill.
1853*g*	.....	.....	.....	.....	9.92	10.58	11.00	10.50	11.33	11.08	.....	10.75	Eagle River.	C. Whittlesey.
1854*h*	.....	.....	9.75	10.25	10.37	10.75	11.17	11.33	11.54	11.75	11.58	11.25	.....do	Do.
1855*i*	11.08	11.21	11.29	11.29	11.37	12.08	12.50	12.83	12.90	13.24	13.00	.....	S.Ste.Marie.	Wm. Finney.
1856*i*	.....	.....	.....	.....	12.25	12.58	12.75	13.09	13.35	13.19	.....	.....	.....	M. B. Sherwood.

a Reported to be at the lowest level.
b Reported by Major Lachlan as 3 feet higher than 1828, and 1 foot above 1837.
c Not measured, but high.
d From 2 to 3 feet below general level of 1845.
e Rise from June to September 12 inches.
f This by a mark on rock of Ducks Island, near end of Turrills dock, and compared with 1855.
g Means of frequent observations during months, Copper Harbor.
h Mark or zero transferred to Eagle River dock.
i Taken frequently during month under direction of Mr. Burt, superintendent of canal.

The elevation of the upper miter sill of lock is given as 588.30 feet by Mr. E. S. Wheeler, United States assistant engineer, Sault Ste. Marie, in letter dated October 26, 1896. This is assumed to be the same as the miter sill referred to by Whittlesey.

GENERAL NOTES BY WHITTLESEY.—In 1847, trees 100 years old within 4 feet of level.

In 1851, this being at the time the highest then known, state of water and mark as above with comparison of 7 months of 1855–56, corresponds to 12 feet 3 inches in the canal.

All those who journeyed along the shores of this lake in 1845–46 observed that the summer months were unusually dry. Fires occurred in swamps that held water long enough for cedar trees to grow up and die of old age. Surface of lake declined in those years and still more in 1847; according to general estimate, 3 feet.

Register of Messrs. Finney and Sherwood at Sault Ste. Marie show the effect of winds in a narrow crooked strait connecting two bodies of water. Readings were taken at upper and lower locks 1855–56, and show a difference of 2 feet 9 inches in 8 hours, the wind having shifted 180°.

LAKE SUPERIOR, AT SUPERIOR.

[From Report of Chief of Engineers, U. S. A., 1876, Part III, p. 91. Readings are below lake survey plane of reference or high water of 1838. (Elevation, 604.76 feet.)]

Year.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Mean
1859	.....	.....	.....	.....	.....	.....	1.25	1.16	1.23	1.51	1.56	.....	.....

This period is also covered by records at Ontonagon, Marquette, and Sault Ste. Marie, published in reports of the Chief of Engineers for 1860 and 1870. The several records do not agree, and the record at Superior is given as the least liable to be in error.

GENERAL NOTES.

From Foster and Whitney's Report of Land District of Superior (Senate Ex. Doc. No. 4 special session, 1851.) Article by Charles Whittlesey: The surface of Lake Superior was, on 12th August, 1849, 23¼ inches higher than in May, 1847. At this time (November, 1851) Lake Superior is unusually high. During the summer of 1851 it was about 3 feet above the general level of 1847, when it was unusually low.

From Maj. R. Lachlan's article in American Journal of Science, vols. 69 and 70, pp. 60–164, 45, 1855: Superior, in 1838, 3 feet higher than usual and 1 foot above 1837. In 1844 all the lakes considered low. In Lake Superior, 1845, a rock appeared above

water at the entrance to Eagle Harbor, next year (1846) was 1½ feet high, and next year (1847) still higher.

From article by J. W. Scott, in Hunt's Merchant Magazine, vol. 8, p. 77, 1843: The waters of the lakes became stationary, or, as some say, began to fall in the summer of 1839, since which time they have constantly receded.

From article by J. J. Bigsby, Physical Geography of Lake Superior, Littell's Living Age, 1852, vol. 35, p. 7: Lake Superior is lowest in April and highest by a few feet in September. The great annual variations of rain in these countries produce corresponding changes of level. There are no tides and no cycle of years for lake levels.

From report of the superintendent Sault Ste. Marie Canal for 1856 and 1858 (joint document Michigan assembly): On the 18th of July, 1855, water fluctuated 3 feet 6 inches; highest, 14 feet 2 inches, lowest, 10 feet 8 inches. On 21st of November, 1856, water rose to 14 feet 6 inches. On the 9th of August, 1858, water rose from 11 feet 9 inches to 15 feet in about forty-five minutes.

LAKE MICHIGAN.

[From original record of Dr. I. A. Lapham, Milwaukee, Wis. Plane of reference is Milwaukee City zero, or low water Milwaukee River, March, 1836, being 4 feet below the H. W. 1838. Readings are + above or — below this plane.]

Year.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Mean
1836	.....	.....	0.00	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
1837	.....	.....	.....	.....	0.80	.....	.....	.....	.....	.....	.....	.....	.....
1838	.....	.....	.....	.....	.....	.....	4.00	.....	.....	.....	.....	.....	.....
1839	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
1840	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
1841	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	—0.43	.....
1842	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
1843	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
1844	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
1845	.....	.....	.....	.....	.....	a0.50	.....	.....	.....	.....	.....	.....	.....
1846	.....	a—0.42	—0.27	0.21	0.57	0.56	(b0.60)	0.35	—0.13	—0.38	—0.66	—1.03	.....
1847	—1.38	—1.50	—1.28	—1.19	—0.98	—0.57	—0.51	—0.56	—0.45	—0.77	—0.88	—1.09	—0.93
1848	—1.29	—1.34	a—1.35	—1.00	—1.30	—1.05	—0.47	—0.46	—0.64	—0.72	—0.82	—0.77	—0.93
1849	a—0.80	a—0.70	—0.90	.....	.....	.....	a0.25	0.25	.....	.....	.....	.....	.....
1850	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
1851	.....	.....	.....	.....	.....	.....	a1.43	a1.70	.....	.....	.....	.....	.....
1852	.....	.....	.....	.....	.....	.....	.....	a2.50	1.98	1.90	2.04	.....	.....
1853	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
1854	.....	.....	.....	0.30	0.95	.....	.....	.....	.....	.....	.....	.....	.....
1855	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
1856	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
1857	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
1858	.....	.....	0.92	c1.20	.....	.....	.....	2.04	.....	2.28	3.31	1.53	.....
1859	1.97	2.13	1.78	.....	.....	.....	.....	.....	2.72	2.51	2.34	2.11	.....

a March 6, 1848, lowest water — 1.65 feet. Result of but one or two observations. Tide gauge observations from September, 1859.

b July, 1846, water only a little above June. From September, 1859, the means are from tide gauge records and observations taken at the foot of Poplar street, Milwaukee. Milwaukee zero = low water of 1836. Colonel Graham's zero = 1.40 feet lower than Milwaukee. Chicago zero = 0.55 foot lower than Milwaukee, proved by comparing results of tide-gauge observations. United States Lake Survey zero = 5 feet higher than Milwaukee.

c April 8, 1858, a great swell that upset a ferry boat. May 31, 1858, 6 a. m., a swell 3.14 feet high.

REMARKS.—The elevation of high water of 1838 = 584.34 feet and plane of reference is 584.34 — 4, or 580.34 feet. Note in Dr. I. A. Lapham's record: "Milwaukee zero (March, 1836) about 3 feet above low water of 1819 and 1820." As high water of 1838 is 4 feet above Milwaukee zero, then high water of 1838 is 4 + 3 = 7 feet above low water of 1819 and 1820. From low water of March 6, 1848, or—1.65 to high water 1838, or + 4, the range is 4 + 1.65 = 5.65 feet.

[From record in report of W. H. Clark, assistant engineer, board of public works, Chicago, 1865. Plane of reference is Chicago datum; readings are above, or plus.]

Year.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Mean.
1856	1.90	1.41	1.43	1.56	1.99	1.92	1.99	1.80	1.68	1.49	1.43	1.20	1.60
1857	1.00	1.28	.....	1.87	2.22	2.52	2.95	3.14	2.99	3.06	2.25	2.29	2.42
1858	2.22	1.93	1.85	2.37	2.85	3.27	3.66	3.62	3.22	3.07	(a)	2.76	2.90
1859	2.27	2.40	2.46	3.10	3.25	3.25	3.90	3.60	3.36	3.03	2.53	2.60	2.98

a The reading for November, 1858 (3.86), is probably in error, and is omitted from table. A comparison of seven months of 1859 gives Chicago datum as used by Mr. Clark as 0.52 foot below Milwaukee datum, used by Dr. Lapham. In reducing, the value 4.55 feet as used by Dr. Lapham is adopted.

NOTE.—Dr. I. A. Lapham notes that "Chicago zero or datum is 0.55 foot lower than Milwaukee," hence Chicago datum is 580.34—0.55, or 579.79 feet.

[From record of Col. J. D. Graham, kept at Chicago and published in the Chief of Engineers' reports. (Ex. Doc. Thirty-fifth Congress, first and second sessions, vol. 7, p. 7, and vol. 2, pt. 3, p. 1105.) Readings are above zero of gauge on east end of north pier. Elevation of zero is 580.34—1.40 = 578.94 feet.]

Year.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Mean.
1854	.....	.....	.....	.....	.....	.....	.....	.....	2.79	2.22	1.95	1.87	.....
1855	1.61	Frozen.	1.65	1.73	2.40	2.63	2.72	2.83	2.92	2.79	2.59	2.69	.....
1856	Frozen.	2.40	2.29	2.42	2.83	2.77	2.84	2.66	2.56	2.34	2.25	2.25	.....
1857	2.00	2.13	Frozen.	2.71	3.07	3.46	3.80	3.99	3.84	3.91	3.14	3.11	.....
1858	3.04	2.78	2.90	3.22	3.70	4.13	4.51	4.47	4.08	3.93	.....	.....	.....
1859	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....

NOTE.—Dr. I. A. Lapham notes that Col. J. D. Graham's zero is 1.40 feet lower than Milwaukee and 0.85 foot lower than Chicago.

NOTE BY COLONEL GRAHAM.—Gauge established at well of city works, and one at Rush street, on river. The zeros all set at the same plane.

A comparison of three years shows Colonel Graham's zero to be 0.89 foot below Chicago datum as used by Mr. Clark, or 4.52+0.89=5.41 below high water of 1838. In reducing the value, 5.40 feet as used by Dr. Lapham is adopted.

GENERAL NOTES AND TABLES.

From Michigan Geological Reports and quoted by Dr. I. A. Lapham in his notes. Readings are above low water of 1819–20: 1800 or 1802, very high; 1814 and 1815, unusually high; 1819 and 1820, zero; 1828, 2.83 feet; 1830, 2.83 feet; 1836, 3.67 feet; 1837, 4.08 feet; 1838, 4.67 feet; 1839, 3.92 feet; 1840, 2.58 feet.

From article by Maj. Henry Whiting in Americal Journal of Science, vol. 20: A few observations by Governor Cass on Green Bay, above an arbitrary zero: July, 1828, 0.64 foot; August, 1828, 0.58 foot.

In normal fluctuations, August is the same as June.—J. E. Maloney.

From article by Charles Whittlesey in Smithsonian Contribution to Knowledge, Vol. XII, 1860: Lakes Huron and Michigan have not received much attention, but are known to have been high in 1838 and low in 1819. It does not necessarily follow that the highest or lowest level of different lakes will occur at the same time nor that the quantity of rise and fall will be the same.

From Foster and Whitney's Report, Land District of Wisconsin (article by Charles Whittlesey): At this time (November, 1851) Lake Huron is stated to have been 2½ feet higher at the detour light than in 1847. Lake Michigan is reported to have been higher the past autumn than for several years.

From article by J. W. Scott in Hunt's Merchant Magazine, vol. 8, 1843: The waters of the lakes became stationary—or, as some say, began to fall in the summer of 1839, since which time they have constantly receded.

From article by Maj. R. Lachlan in American Journal of Science, vols. 69 and 70, 1855: In 1819 and 1820 the central and lower lakes described by Messrs. Higgins and Whittlesey as unusually low, while Dr. Houghton and Colonel Whiting state that the Detroit River had resumed its usual level. In 1838 Lake Huron higher than for two centuries. In 1838 Lake Michigan 6 feet higher than in 1820. In 1844 all the lakes low. In 1845 Lakes Huron and Michigan much lower than usual.

From article by Charles Whittlesey in American Journal of Science, vol. 77, 1859: Observations by Mr. Underwood at Green Bay, for August and September, 1858, below zero: August, 1858, 0.70 foot; September, 1858, 0.84 foot.

LAKE HURON—POINT AUX BARQUES.

[Plane of reference being high water of 1838. From Report of Chief of Engineers, 1876. Elevation of plane of reference = 584.34 feet.]

Year.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Mean.
1859	1.38	1.08	0.90	0.99	1.26	1.46	1.72	1.82	.....

LAKE MICHIGAN—MILWAUKEE.

[Plane of reference being high water of 1838. From Report of Chief of Engineers, 1876. Elevation of plane of reference = 584.34 feet.]

Year.	Aug.	Sept.	Oct.	Nov.	Dec.	Mean.
1859	1.08	1.38	1.47	1.88	1.94	.....

LAKE MICHIGAN.

[From Foster and Whitney's report on Geology of Land District of Wisconsin. Article by Charles Whittlesey.]

Dr. Houghton gives the following table of heights from a comparison of his own observations on Michigan, Huron, and Superior with those of Higgins, Whiting, and Hathan for month of June each year, taking lowest stage of water, 1819–20, as a zero:

	Feet.		Feet.
June, 1819–20	0.00	June, 1836	3.67
June, 1828	2.83	June, 1837	4.08
June, 1830	2.83	June, 1838	4.67

If figured from February, 1820, to June, 1838, the total amount would be about 6.67 feet. (Geological Rep., Mich., 1839, p. 24.)

Mr. S. W. Higgins, in the Michigan Geological Report above referred to, uses the same zero as Dr. Houghton in 1838, but differing slightly as to the extreme rise of 1838 above the depression of 1819.

Feet above low water, 1819:		Feet above low water, 1819—Continued.	
1838	5.25	1840 (maximum)	2.63
1839 (minimum)	1.58	1841	0.54
1839 (maximum)	3.92	1840 (above low water of 1819–20).	
1840 (minimum)	0.75		

Year.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1840	0.75	.....	.....	2.17	2.29	2.37	2.50	.....	2.02	1.87	1.09	1.46
1841	0.54	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....

DETROIT RIVER.

[From record furnished by engineers of Detroit waterworks, through Mr. G. Y. Wisner, C. E.]

Year.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Mean
1819	.....	.....	.....	.....	.....	8.50	.....	.....	.....	.....	.....	.....	.....
1830	.....	.....	.....	.....	.....	6.50	.....	.....	.....	.....	.....	.....	.....
1836	.....	.....	.....	.....	.....	4.83	.....	.....	.....	.....	.....	.....	.....
1837	.....	.....	.....	.....	.....	4.17	.....	.....	.....	.....	.....	.....	.....
1838	.....	.....	.....	.....	.....	.....	8.17	3.42	4.17	5.17	5.17	.....	.....
1839	6.92	.....	.....	.....	.....	4.83	4.50	.....	5.33	6.00	6.00	.....	.....
1840	7.75	.....	.....	6.33	6.17	6.17	6.00	.....	6.50	6.58	6.83	7.00	.....
1841	7.92	7.92	8.00	7.58	7.75	7.50	7.00	6.58	7.42	8.83	7.83	7.58	.....
1842	7.50	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
1847	.....	.....	.....	.....	.....	.....	.....	.....	.....	6.08	.....	.....	.....
1849	.....	.....	6.33	.....	5.50	.....	.....	.....	.....	.....	.....	.....	.....
1850	.....	.....	.....	.....	.....	.....	5.58	.....	.....	.....	.....	.....	.....
1853	.....	.....	.....	4.58	.....	3.83	3.75	3.92	4.08	4.42	4.58	4.75	.....
1854	5.60	5.92	5.50	4.83	4.75	4.33	4.33	4.50	4.75	5.58	5.50	5.83	.....
1855	5.33	5.75	5.33	5.33	4.92	4.58	4.17	4.17	4.42	4.58	4.58	4.83	.....
1856	4.42	4.50	4.75	4.92	4.75	4.58	4.50	4.58	4.92	5.00	5.58	5.33	.....
1857	6.00	3.75	5.50	5.00	4.42	4.08	3.83	3.83	3.92	4.08	4.42	4.42	.....
1858	4.33	4.08	4.33	4.08	3.75	2.83	2.92	3.08	3.50	3.75	3.92	4.00	.....
1859	3.83	4.00	4.00	3.58	3.42	3.58	3.33	3.42	3.83	4.33	4.50	3.75	.....

REMARKS.—Readings are below water table of Orleans street engine house (engine house removed from Orleans street in 1878 to the new grounds at eastern city limits, and gauge set there at the same elevation, which is 100 feet above city datum, and 580.30 feet above mean tide at New York City). The observation of 1819 was made by Maj. Henry Whiting. The observations from 1830 to 1850, inclusive, by A. E. Hathan, who was for many years the city surveyor. The observations since 1850 were made daily, by direction of Jacob Houghton, jr., superintendent and engineer Detroit waterworks. The figures in the columns show the monthly means. The observations made before the engine house was erected (1858) were made with reference to a known point, and were afterwards by calculation referred to present base.

This record is also given in part in Foster and Whitney's report, and in report of Captain Whipple, U. S. A. (Ex. Doc., Thirty-fifth Congress, second session, vol. 2, pt. 3).

From article by Charles Whittlesey, in Smithsonian Contributions to Knowledge, Vol. XII, 1860: Dr. Houghton has mentioned one observation made sometime in the winter 1818–19 by which the water in the Detroit River was 6.67 feet below flood of 1838. The old French inhabitants of Detroit have no tradition of a water level below that of the year 1819, although Detroit has been occupied since 1702.

From article by Maj. Henry Whiting, U. S. A., in American Journal of Science, vol. 20: It is now a matter of record that in 1814 to 1815 the St. Clair and Detroit rivers were unusually high. Abrupt and considerable changes in the level of the Detroit River are frequently observed; within twelve hours there will sometimes be a difference of 2 or 3 feet. The rivers continued at this unusual height (1830) until January, 1831, when in the course of eight or ten days they subsided 3 or 4 feet, and they have now maintained the minimum level for about six weeks. Two hydraulic works which had been established in connection with the river the last season were left by this subsidence above high water, and had to extend their source pipes.

LAKE ERIE.

[Article by Charles Whittlesey, in Smithsonian Contributions to Knowledge, Vol. XII, 1860. Readings reduced to depth on miter sill of enlarged Erie Canal.]

Year.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Locality.	Observer.
1819								6.30					Black Rock	
1820[a]								6.30					....do	
1822[b]													Cleveland	A. Carter.
1823[c]													Canada	McTaggart.
1825[d]													Cleveland	A. Wolworth.
1826[e]													....do	A. Merchant.
1827[f]													Canada	McTaggart.
1832[g]													Cleveland	A. Wolworth.
1833[h]													....do	Do.
1834[i]						8.82							....do	Do.
1835						8.57			8.07				....do	Do.
1837[j]	8.30					8.82		10.07					Buffalo	J. Lathrop.
1838[k]					10.39	11.40	11.15	10.64	10.10	9.89		9.46	Cleveland	G. C Davis.
1839	7.74				9.50	9.83	10.08	10.13	9.33	10.30			Black Rock	Commercial Advertiser of Buffalo.
1840					10.33	10.90	10.33	10.40	9.30	9.10			....do	Do.
1841			8.65		9.50	9.24	8.80	8.30	7.75	6.87			....do	Do.
1842	8.99				9.50								....do	Do.
1843					8.96								....do	Do.
1844					9.21								....do	Do.
1845[l]					9.30			8.71	8.43	8.27	7.84	7.60	Cleveland	Col. T. B. W. Stockton.
1846	7.34	6.97	6.91	7.30	8.26	8.57	8.57	8.34					....do	Do.
1847					8.80					8.50			....do	Do.
1848					8.46					8.94			Buffalo	Commercial Advertiser.
1849					9.40								....do	Do.
1850					8.96	8.49					7.71	7.83	....do	J. Lathrop.
1851	7.88	7.86	8.40	8.47	8.59	9.34	9.46	9.34	9.07	9.13	9.21		....do	Do.
1851	7.49					9.49	9.46	9.49	9.15	9.99	8.74	8.50	Cleveland	C. Whittlesey.
1852	8.35	8.07	8.42	9.47	10.07	10.30	10.20	9.97	9.61	9.35	9.10	9.07	....do	B. Stanard.
1853	9.56	9.40	9.49	10.07	10.15								....do	C. Whittlesey.
1856											8.30	7.90	....do	Do.
1857		8.15	8.15	8.78	9.65	9.90	10.15	9.99	9.60	9.55	9.32	9.32	....do	Do.

[a] Old residents of Buffalo state as low as 1819.
[b] Rising, 4 feet below June, 1838.
[c] Rising, 3 feet 3 inches below June, 1838.
[d] Rising, lowest 3 feet below June, 1838.
[e] Rising, lowest 2 feet 10 inches below June, 1838.
[f] General level of 1815.
[g] Average, 2 feet 10 inches below June, 1838.
[h] Average, 3 feet 2 inches below June, 1838.
[i] Mr. Wolworth was first Government agent at this harbor.
[j] Engineer on Erie Canal.
[k] July to October, measurements several times a day.
[l] Government agent at this point.

NOTE.—Report of New York State engineer and surveyor for 1888, p. 269, gives canal bottom 563.23, and as canal levels are 1.30—0.67, or 0.63 foot below Lake Survey, canal bottom west of guard lock is 563.23 + 0.63 = 563.86 feet.

Buffalo Commercial Advertiser occasionally published measurements, but original record not to be had. 1830, water rising (Houghton, Geological Report, Michigan, 1839). 1831, general level same as 1828, A. W. Higgins (Michigan, 1839). At Buffalo the year 1810 is remembered as one of low water, nearly or quite as low as 1819. As the lake is broad opposite Cleveland, and the place is situated not far from the middle, its surface would be less affected by winds, and here the level during the summer of 1819 is regarded as the lowest. But if that year did not differ from other years in the period of annual rise and fall, it must have been still lower in the winter than in the summer months.

From article by Charles Whittlesey, in Smithsonian Contributions to Knowledge, Volume XII, 1860: At Cleveland high water of 1838 used as a zero, counting down to the water surface. This line was 2 feet below surface of east pier at south end of steps leading up to parapet wall. As the records at different places are but seldom of the same dates, it is not easy to bring them into comparison with each other. To effect this in the only manner they admit of, I neglect the descent of the Detroit River from that city to the lake, and regard the surface of the lake as level. The longest period of the Detroit tables which correspond with those at Cleveland was compared by the mean of both, which gave the elevation of the stone water table of the hydraulic tower above the Cleveland zero as 3.43 feet. By Mr. Hathan's register this was 3.2 feet in June, 1838, above surface of the river. In July, Lathrop, at Buffalo, and Whittlesey, at Cleveland, kept registers, weather calm, fluctuations small. High water of 1838 by this comparison corresponds to a depth of water in the enlarged Erie Canal of 11.85 feet. The base of the hydraulic tower is therefore 14.85 feet above bottom of canal. The miter sill of the guard lock at Black Rock was at first used by the engineers of the State of New York on which to register the depth of the water. When the enlargement of the Erie Canal was commenced, John Lathrop, C. E., transferred the measurements to the bottom of the canal at Buffalo, which is 1 foot below the miter sill of the guard lock.

From Foster and Whitney's Report on Geology of Land District of Wisconsin (Senate Ex. Doc. No. 4, special session, March, 1851). Article on Water Levels, by Charles Whittlesey: For the zero at Cleveland in 1838, I made use of one of the courses of masonry on the east pier of the harbor at its southern extremity, being then the bottom of the first course from the top, but since the coping has been laid it is at this time the second. The zero (high water of 1838) of June 25, 1838, was 6 feet below the surface of the southern end of the parapet wall as it now stands, October, 1851. Different observers do not agree as to the highest or lowest stages of water. At Cleveland it was unquestionably highest about June 25, 1838, when it was 2.42 feet below surface of main wall at south end of east pier; 2 feet below the same wall 400 feet from south end, and 6.33 feet below the coping of the lock, west wing wall, Merwin street and Cuyahoga River. These marks by Mr. Howe, engineer Ohio Canal, General Merchant, Colonel Stockton, and myself. At the other end (Buffalo) of the lake accounts differ as to the fact of the lowest water being in 1819 or 1820, but the difference between the two years was slight. At Black Rock the highest stage of water is stated to have been in August, and not in June, 1838, but at Buffalo it is given as June. At Buffalo and Black Rock there is less regularity than elsewhere, showing that winds and the form of coast produce irregularities there which are local. But if we reduce the observations at Black Rock to the standard, we find that the low water of October, 1841, was below the level of 1819, when it is universally agreed that this was the lowest stage known. Mr. Lathrop remarks that the depth of water on miter sill of guard lock at Black Rock is very much influenced by the mills which are fed from that basin. The records show that the fluctuations are greater at Black Rock than at either Cleveland or Detroit.

From History of Cleveland, Ohio, by Charles Whittlesey, 1867: Elevation of top of east pier at Cleveland over bottom of enlarged Erie Canal is 13.42 feet.

[From Foster & Whitney's Report on Geology of Land District of Wisconsin. (Article on Water Levels, by Charles Whittlesey.)]

	Feet.		Feet.
1822	5.00	1833	3.17
1825	4.0	1834	2.58
1826	2.83	1835	2.83
1832	2.83		

Year.	Jan.	May.	June.	July.	Aug.	Sept.	Oct.	Dec.
1837	3.10		2.58			3.50		
1838*a*		1.00	0.33	0.25	0.75		1.75	1.96

a On June 25, 1838, the reading was 0.00 feet.

REMARKS.—Availing myself of information from Messrs. Wolworth, Merchant, and others at Cleveland, 1824–1837, I have constructed the above table. Readings are below high water of 1838. This is assumed to be the same as Whittlesey observed, or at an elevation of 575.17 feet.

From August 18 to October 18 Mr. G. C. Davis kept a floating register. Readings are below high water of 1838 at Cleveland (elevation of 575.17 feet).

	Feet.
August, 1838	0.81
September, 1838	1.22
October, 1838	1.61

Abstract of Col. T. B. W. Stockton's register for Cleveland, 1845–46, below zero.

Year.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1845									2.95	3.18	3.47	3.80
1846	4.05	4.39	4.47	4.10	3.13	2.84	2.89	3.06				

My observations at Cleveland, 1838–1851, have not been sufficiently numerous or regular to be of much value. They are as follows, below high water of 1838 (elevation of 575.17 feet):

Year.	Date.	Feet.	Year.	Date.	Feet.
1841	Mar. 11	2.75	1846	Apr. 15	3.50
1842	Apr. 14	2.50	1850	June 20	3.00
1845	Dec. —	2.42	1851	Jan. 18	4.08

	Feet.
June, 1851	1.92
July, 1851	1.95
August, 1851	1.94
September, 1851	2.25
October, 1851	2.48

[At Black Rock guard lock, from the Buffalo Commercial Advertiser, November 12, 1841, being depth of water on the miter sill in feet (elevation of miter sill assumed as 564.86 feet).]

Year.	May.	June.	July.	Aug.	Sept.	Oct.
1840	9.33	9.90	9.33	9.40	8.30	8.10
1841	8.50	8.24	7.80	7.30	6.75	5.86

Abstract from register of J. Lathrop, resident engineer Erie Canal, being height above bottom of enlarged Erie Canal.

[Elevation of bottom of canal assumed as 563.86 feet.]

Year.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1850											7.73	7.83
1851	7.91	7.85	8.46	8.49	8.90	9.33	9.50					

Abstract from register of J. Lathrop, resident engineer Erie Canal, etc.—Continued.

["At Black Rock, from Commercial Advertiser, November 12, 1841, referring to low water of 1820 as zero."

Date.	Rise.	Date.	Fall.
	Feet.		*Feet.*
August, 1820, to August, 1828	2.50	August, 1838, to August, 1839	1.25
August, 1828, to August, 1830	.....	August, 1839, to August, 1840	1.25
August, 1830, to August, 1836	1.00	August, 1840, to August, 1841	1.83
August, 1836, to August, 1837	.50		
August, 1837, to August, 1838	1.08		

Abstract from original manuscript of Charles Whittlesey, by Mr. William T. Blunt, United States assistant engineer.

[Courtesy of Mr. Peter Neff, secretary Western Reserve Historical Society. Reading in feet below zero or high water of 1838. Observations at Cleveland.

Year.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1857	.....	.....	.....	.....	.....	.....	.....	.....	1.79	1.85	2.08	2.08
1858	1.75	2.00	2.08	1.40	0.61	*a*0.14	0.15	0.59	0.86	1.20	1.26	1.32

a June 19 reading was —0.25 or 0.25 feet higher than 1838.

[From article by Maj. R. Lochlan in American Journal of Science, vols. 69 and 70, 1855. Readings are from low water of 1819 as zero.]

Year.	Comparative level.	Authorities.
1790	5.50 feet above zero	Professor Hall, Whittlesey, and others.
1795–96	Described as low	Weld, Whittlesey, and others.
1800–1802	High	Higgins, Houghton, and others.
1806	Low	Whittlesey.
1810–11	6 feet below 1838	Do.
1815	2 feet below 1838	Do.
1816	.....do	Do.
1817–18	Falling	Higgins, Houghton, and others.
1819–20	Zero	Do.
1821	Rising rapidly	Higgins, Houghton, Dearborn, and McTaggart.
1822	Rising, but still low	Higgins, Houghton.
1823	Up to an average	
1824–1826	2 feet below 1838	
1827–28	As high as 1815	Houghton, etc.
1830	Same as 1828	
1831	Subsiding	
1832–33	2.75 feet below 1838	Whittlesey, etc.
1835	2.83 feet below 1838	Higgins, Houghton, and Mather.
1836	1.67 feet below 1838	Higgins, Houghton, Mather, Whittlesey, etc.
1837	0.75 foot below 1838	Do.
1838	5.25 feet above zero	Do.
1839	3.67 feet above zero	American Journal of Science; Professor Dewey; Buffalo Express.
1840	3.42 feet above zero	Do.
1841	3.08 feet above zero	Do.
1842	3.58 feet above zero	
1843	2.67 feet above zero	
1844	2.92 feet above zero	
1845	3 feet above zero	
1846	2 feet above zero	
1847	2.50 feet above zero	
1848	2.17 feet above zero	
1849	3.08 feet above zero	
1850	2.67 feet above zero	
1851	2.92 feet above zero	
1852	Rising rapidly	
1853	High as in 1852	

In 1838 Lake Erie stated by Higgins to be 5.25 feet above 1819, and by Buffalo Advertiser 5.33 feet in June, and 5.75 feet in August, and according to Dr. Houghton it might be 6 feet. Much land overflowed and trees of a hundred years' growth were killed. By February, 1839, Erie had fallen to 3.67 feet and in 1840 it was higher than for twenty-three years, excepting 1838. (See Buffalo Advertiser April, 1851.)

From a report on Buffalo Harbor (House Ex. Doc., 30th Cong., 2d sess., Vol. IV): Lake Erie unusually low in 1809, Deacon Collender drove cattle in September from Huron to Buffalo crossing every stream, except Rock River, by wading. In October, 1844, water raised 10 feet by gale at Buffalo, and at Dunkirk 2 or 3 feet below Buffalo at flood. Prevalent winds from the SW.

[From Lake Survey (Report Chief of Engineers, 1876, Part III). Readings below plane of reference or high water of 1838. Elevation = 575.20 feet.]

Year.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Mean.
CLEVELAND.													
1859	.....	.....	.....	.....	.....	.....	0.76	0.87	1.28	1.64	1.98	1.68	.....
PORT COLBORNE.													
1854	.....	.....	.....	.....	.....	.....	.....	1.94	2.27	2.41	2.11	2.09	.....
1855	2.72	3.03	2.97	2.68	2.16	1.88	1.38	1.16	1.81	1.57	1.50	1.22	2.01
1856	1.86	2.26	2.59	2.10	2.14	1.76	1.73	1.88	2.13	2.79	2.91	2.62	2.23
1857	3.37	3.34	(a)	(a)	1.61	1.23	1.14	1.18	1.43	1.89	1.35	1.35	.....
1858	1.26	1.66	1.63	1.52	1.26	—.10	—.05	.04	.60	.70	1.12	1.02	.89
1859	1.03	1.25	.84	.27	.39	.42	.36	.66	1.26	1.05	1.23	1.43	.85

a The readings for March and April, 1857, 1.75 and 1.20, respectively, as published are assumed to be in error and are omitted.

LAKE ONTARIO AT OSWEGO.

[Record furnished by Mr. Wm. Pierson Judson, C. E., from personal files of his father, Mr. J. W. Judson, C. E.]

[Measurements upward and above an arbitrary bench mark. Elevation of bench mark or zero = 244.21 feet.]

Year.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Mean.
1837	3.33	.....	.....	.....	.....	.....	3.16	.....	.....	.....	.....	.....	.....
1838	.....	.....	.....	.....	.....	.....	4.75	.....	.....	.....	.....	.....	.....
1839	2.50	.....	.....	.....	.....	.....	.....	3.41	.....	.....	.....	.....	.....
1840	.....	1.50	.....	.....	.....	3.75	.....	.....	.....	.....	.....	.....	.....
1841	.....	.....	1.75	.....	.....	3.33	.....	.....	.....	.....	.....	0.66	.....
1842	.....	.....	.....	.....	.....	.....	2.50	.....	.....	.....	.....	1.08	.....
1843	.....	.....	.....	.....	.....	2.83	.....	.....	.....	.....	.....	.....	.....
1844	1.16	.....	.....	.....	.....	.....	.....	2.58	.....	.....	.....	.....	.....
1845	.....	.....	.....	.....	.....	2.66	.....	.....	.....	.....	.....	.....	.....
1846	.....	.....	0.00	.....	.....	1.41	.....	.....	.....	.....	.....	.....	.....
1847	.....	.....	1.25	.....	.....	2.66	.....	.....	.....	.....	.....	.....	.....
1848	.....	.....	.....	.....	.....	1.58	.....	.....	.....	.....	0.00	.....	.....
1849	.....	.....	.....	.....	.....	2.00	.....	.....	.....	2.00	.....	.....	.....
1850	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
1851	.....	.....	.....	.....	.....	2.41	.....	.....	1.66	.....	.....	.....	.....
1852	.....	.....	.....	.....	.....	3.33	.....	.....	.....	.....	.....	.....	.....
1853	.....	.....	.....	.....	.....	4.41	.....	.....	.....	.....	.....	2.25	.....
1854	.....	.....	.....	.....	.....	4.41	.....	.....	.....	.....	1.16	.....	.....
1855	.....	.....	0.67	.....	.....	.....	.....	2.75	.....	.....	.....	2.00	.....
1856	.....	.....	1.58	.....	.....	3.00	3.08	2.75	.....	.....	.....	0.83	.....
1857	0.66	.....	.....	.....	.....	3.08	.....	.....	.....	.....	.....	3.83	.....
1858	3.66	.....	.....	3.33	.....	4.66	.....	.....	4.41	.....	.....	.....	.....
1859	.....	.....	.....	.....	.....	4.67	4.25	4.00	.....	.....	.....	2.66	.....

REMARKS.—This record is exactly duplicated by that published in New York Meteorology, 1850–1863, by F. B. Hough (New York Library).

The only discrepancy is the reading of March, 1855, given by Mr. Judson as 2.75 feet and by Mr. Hough as 0.67; as 0.67 seems to agree with the record at Port Dalhousie, it is accepted as correct.

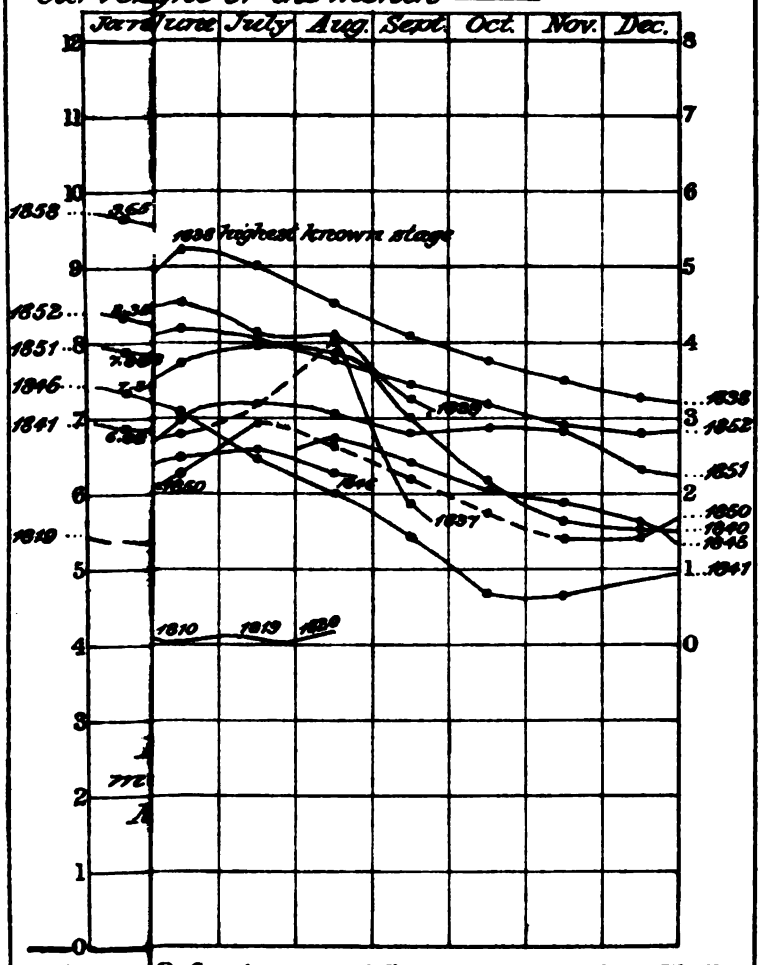
The zero readings of March, 1846, and November, 1848, are from Mr. Judson's record, and are not given by Mr. Hough.

These readings are probably from single observations.

Mr. Wm. Pierson Judson in letter of February 20, 1896, gives the following information in regard to the zero or arbitrary mark used above: "In 1838 my father (John W. Judson, graduate of West Point, class of 1836), who was for many years United States agent in charge of Lake Ontario works, established the zero of the Oswego gauge at what he determined to his satisfaction was extreme low water level, though at that time the lake was extremely high. He found in 1838 an entire lack

Wade Western Reserve Historical
Society. retary and Librarian, Mr. Peter Neff.

Show the relative height of water in Lake Erie
1845– being the mean of each month so far as
measurements - the years 1841, 1851 &
Miter soundings.
Curve ght of the month ——



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...opy made Nov. 11- 1896.
Wm T. Blunt U.S. Asst. Engr.

THE WERNER

of knowledge of lake fluctuations, and saw that a record of them was necessary to intelligent work. Among other evidence he found an old resident who lived on the lake shore and who told him of a time about twenty years ago (evidently in 1819) when the lake was the lowest ever known, and when the rock ledges were dry far out from shore. He said he had there quarried the rock, and had drilled one hole around which he expected to make a clay dam to keep his powder dry. His drill was jammed in the hole when the waves arose and drove him away, and later broke off the drill. They went out in a boat and found the broken drill in the hole, and this was taken as the zero level which has since been used."

The elevation of this zero is 244.21 feet.

RECORD AT OGDENSBURG, NEW YORK.

A record of water levels at Ogdensburg from 1851 to 1857 is given in New York Meteorology, 1850–1863, by F. B. Hough (New York State Library). As no compilation of records prior to 1860 along the St. Lawrence River has been attempted in this exhibit, this table is omitted.

LAKE ONTARIO AT CHARLOTTE, N. Y. (MOUTH OF GENESEE RIVER).

[Monthly mean of water levels below a fixed point. From article by Prof. C. Dewey in American Journal of Science, vol. 77, and also given in New York Meteorology, 1850–1863, by F. B. Hough (New York State Library).]

Year.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Mean.
1846	4.25	4.50	4.00	3.75	3.50	3.25	3.25	3.50	3.75	3.75	4.00	3.75	3.77
1847	4.00	3.50	3.00	3.00	2.42	2.08	2.08	2.08	3.00	3.25	3.58	3.83	2.99
1848	2.42	2.83	3.58	3.17	3.17	3.08	3.17	3.25	3.67	4.08	4.50	4.42	3.44
1849	4.17	4.17	4.33	3.83	3.00	2.75	3.67	3.25	3.75	3.17	3.17	3.42	3.56
1850	3.75	3.33	3.33	3.33	2.67	2.42	2.83	3.83	3.92	4.33	4.58	3.58	3.49
1851	3.67	4.50	4.00	3.92	3.67	3.17	2.92	3.17	3.50	3.92	4.42	4.25	3.76
1852	4.17	4.25	4.00	3.67	2.17	2.17	1.83	2.00	2.50	1.92	3.17	2.83	2.89
1853	2.92	2.67	2.67	2.08	1.67	1.17	2.25	1.67	2.00	2.33	3.17	3.25	2.32
1854	3.25	3.25	3.17	3.17	2.25	2.00	2.08	2.25	3.00	3.67	4.00	4.17	3.02
1855	4.33	4.42	3.00	3.33	3.33	3.00	2.83	3.00	3.00	2.83	2.75	2.75	3.21
1856	2.92	2.92	2.75	2.58	1.92	1.50	1.92	2.50	3.08	3.83	4.42	4.42	2.90
1857	4.50	4.67	3.83	3.67	2.92	2.00	1.58	1.00	1.17	0.75	2.00	1.83	2.49
1858	1.58	1.08	1.08	1.50	0.33	0.50	0.33	0.17	0.67	1.00	1.17	1.33	0.90
1859	1.67	2.00	1.33	0.83	0.50	0.17	0.67	0.92	1.42	1.83	2.33	2.08	1.31

REMARKS.—These readings were taken on the first day of each month. Taken by H. T. Spencer, from 1846 to 1855, and by Luther Jeffords, from 1855 to 1859, and reported by Prof. Chester Dewey, of Rochester.

There are some slight differences in the record as given in the two publications mentioned, and that which seemed most consistent was accepted.

The average difference between the record from 1846 to 1859 at Oswego and this is about 4.92 feet, the Oswego record being above zero and this down. Hence the elevation of the fixed point used as zero is approximately 244.21+4.92=249.13 feet.

By comparison with Port Dalhousie for the years 1849 to 1859, inclusive, the fixed point is 233.12+(13.45+2.71)=249.28 feet.

Adopted 249.21 as being a mean of the two determinations and exactly 5 feet above above Oswego zero.

"The lowest measured in February 1857, and highest in August, 1858. This same maximum and minimum at Toronto in the months and years. For this fact I am indebted to the accurate observer at that point in Canada West, the harbor master. The range is found to be nearly the same in Lake Michigan. While force of winds make observations not altogether simultaneous at the points differently affected by the winds, still a series of observations must lead to closely approximate results."

LAKE ONTARIO AT CHAUMONT.

[From a record kept by C. V. R. Horton, at Chaumont, Jefferson County, N. Y. Published in New York Meteorology, 1850–1863, by F. B. Hough, New York State Library. The distances are from the top of dock down to the water. Record is of one or two observations.]

Year.	Jan.	Feb.	Mar.	Apr. 1	May. 1	June 1	July 1	Aug. 1	Sept. 1	Oct. 1	Nov. 1	Dec.	Mean
1859	.....	.....	.....	1.25	0.67	0.50	0.67	1.00	1.42	2.08	2.67	2.67	.....

REMARKS.—Mr. Horton remarks that the lake had been higher in 1859 than had ever before been known. Owing to the small amount of rain that fell in the spring and early summer months, it began to fall earlier than usual.

By Judson record top of dock is 244.21+5.15=249.33 feet; by Lake Survey top of dock is 249.04+0.36=249.40 feet; by Port Dalhousie top of dock is 233.12+16.51=249.63 feet. Adopted the mean, or 249.45 feet.

From traditional accounts and the recollection of early settlers the lake at Chaumont was low in 1803, 1804, 1808 to 1811, 1822 to 1828, 1844 to 1850; and high in 1798, 1805 to 1807, 1812 to 1819, 1829 to 1831, 1837 to 1839, 1852, and 1853. It was of middle height in 1820, 1821, 1832 to 1836, 1840, 1841, and 1851. The extreme changes of level, including sudden oscillations, have been almost 5 feet.

On the 15th of June, 1859, the waters rose and fell 21 inches.

LAKE ONTARIO AT PORT DALHOUSIE.

[Readings are depth of water on miter sill of entrance lock, Welland Canal, at Port Dalhousie.]

Year.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Mean.
1849	12.74	12.70	12.90	13.26	13.88	13.92	12.86	12.45	12.15	11.78	11.74	11.64	12.67
1850	11.87	11.99	12.31	12.63	13.11	13.31	12.99	12.55	12.38	12.00	11.60	11.66	12.37
1851	11.60	11.85	12.34	12.89	13.21	13.33	13.21	13.00	12.88	12.37	12.25	12.17	12.60
1852	12.10	12.21	12.55	13.09	13.98	14.47	14.37	13.98	13.58	13.86	13.31	13.31	13.36
1853	13.41	13.49	13.50	13.70	14.38	15.34	14.84	13.91	13.64	13.33	13.25	13.23	13.84
1854	13.10	12.86	12.93	13.31	14.00	14.34	14.40	14.22	13.77	13.10	12.40	11.70	13.34
1855	11.71	11.56	11.71	11.52	12.15	13.38	13.45	13.31	13.57	13.04	12.35	12.31	12.50
1856	11.92	11.41	11.91	12.63	13.40	14.28	14.43	13.99	12.17	12.50	11.99	11.35	12.66
1857	11.33	11.63	12.10	12.64	13.52	14.48	14.59	15.00	14.71	14.34	14.30	14.60	13.60
1858	14.63	14.50	14.40	14.66	15.56	15.84	15.70	15.70	15.29	15.04	14.94	14.91	15.10
1850	14.88	14.75	14.44	15.10	15.51	15.80	15.87	15.71	15.26	14.66	14.08	13.66	14.98

REMARKS.—Elevation of miter sill of old lock, or plane of reference, at Port Dalhousie is 233.12 feet. The reading for September, 1853, is assumed to be 1 foot in error, and is corrected by that amount. This record furnished by Mr. Thomas Monro, engineer Soulanges Canal, letter of September 14, 1896, and is a monthly mean of daily record by lock master. By a comparison of twenty-eight months common to Judson's record at Oswego and this table the miter sill is 10.98 feet below the Judson zero, or 244.21 − 10.98 = 233.23 feet.

LAKE ONTARIO AT FORT NIAGARA.

[From article by Mr. Ew'd Giddings (published in pamphlet, Lockport, N. Y., in 1838, New York State Library). Readings are above a certain zero.]

Year.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Mean.
1815	.....	.....	2.67	.....	.....	.....	5.33	.....	.....	.....	.....	.....	.....
1816	.....	.....	2.50	.....	.....	.....	4.17	.....	.....	.....	.....	.....	.....
1817	.....	.....	3.17	.....	.....	5.08	.....	.....	.....	.....	.....	.....	.....
1818	.....	.....	.....	2.67	.....	4.50	.....	.....	.....	.....	.....	.....	.....
1819	.....	.....	1.75	.....	.....	4.17	.....	.....	.....	.....	.....	.....	.....
1820	.....	.....	1.25	.....	.....	.....	3.17	.....	.....	.....	.....	.....	.....
1821	.....	.....	.....	1.67	.....	.....	4.83	.....	.....	.....	.....	.....	.....
1822	.....	.....	1.92	.....	.....	4.17	.....	.....	.....	.....	.....	.....	.....
1823	.....	.....	2.00	.....	.....	4.50	.....	.....	.....	.....	.....	.....	.....
1824	.....	.....	2.17	.....	.....	.....	4.67	.....	.....	.....	.....	.....	.....
1825	.....	.....	0.67	.....	.....	2.92	.....	.....	.....	.....	.....	.....	.....
1826	.....	.....	0.67	.....	.....	.....	3.17	.....	.....	.....	.....	.....	.....
1827	.....	.....	.....	.....	.....	4.83	.....	.....	.....	4.17	.....	.....	.....
1838	.....	.....	.....	.....	.....	.....	7.17	6.08	.....	5.50	.....	.....	.....

REMARKS.—Register kept at Fort Niagara by Mr. Giddings. Zero is 5 feet below the upper surface of the upper end of the cap sill of the wharf at the mouth of the Niagara River near Fort Niagara. From a comparison of the readings of 1838 Mr. Whittlesey concluded that Mr. Giddings's zero was 10 feet below the Oswego zero (benchmark A = 251.96 feet), or 251.96 − 10 = 241.96 feet. This register reduced and published by Mr. Whittlesey. These readings are from single observations, but are intended to show an average condition. Comparing by July, 1838, with Judson's record, the zero 244.21 − (7.17 − 4.75) = 241.79 feet. Zero = 241.77 adopted as approximately correct. Comparing July, 1838, with Mr. Whittlesey's table gives 251.96 − (3.04 + 7.17) = 241.75 feet.

NOTES.—In 1815, 1816, and 1817 water nearly stationary from November to March; in 1818, from December to April; in 1819 and 1820, from November to March; in 1821, from December to April, and in 1822 to 1826 from December to March.

This record furnished by the New York State Library through the courtesy of the secretary and director, Mr. Melvil Dewey.

LAKE ONTARIO.

[From article by Gen. H. A. S. Dearborn, American Journal of Science, vol. 16. "In 1814 Lake Ontario about 2 feet higher than in 1813." From article by E. Merriman in Hunt Magazine, vol. 28, pp. 91-99. Record kept by Mr. Ousten, keeper of Government light-house on Gull Island. Readings are all above zero. Elevation of zero approximately 244.71 feet.]

Year.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Mean.
1840						2.83						0.75	
1841				1.50					a0.33			.50	
1842			1.17			1.50						.67	
1843				.67	1.75							.67	
1844				1.17	2.00				.75			.33	
1845			1.17		2.17				1.17				

a Fell 14 inches in thirty-six hours.

REMARKS.—Readings are all single observations. From a comparison with Judson's original record of the only month common to the two, the zero appears to be 1.83—1.33 or 0.50 + 244.21 = 244.71 feet. By a comparison of thirteen months with Mr. Whittlesey's deduced table the zero is 251.96—7.05 = 244.91 feet.

Mr. Ousten remarks in report dated December 15, 1846: "The lake commenced rising in October and continued on the rise when the light was discontinued, December 6, at the close of navigation. In August, for the first time since I took charge of the light, I could walk around the tower, the rock upon which it stands being dry. The highest in these records is June 29, 1840, and the lowest August, 1846."

RIDEAU CANAL RECORD AS KEPT AT THE LOCK AT KINGSTON MILLS.

[This table furnished by the Department of Railways and Canals, Dominion of Canada.]

Year.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Mean.
1850	7.81	7.88	7.50	8.17	8.88	8.75	7.89	8.29	8.13	7.42	6.83	7.03	7.88
1853	8.52	8.92	9.27	9.62	10.75	10.92	10.61	9.68	9.53	9.10	8.83	8.81	9.55
1855	7.43	7.25	7.37	7.77	8.25	8.69	9.17	8.50	8.63	8.50	8.13	8.27	8.16
1856	8.50	8.58	8.30	8.50	9.00	9.00	9.00	8.83	8.31	8.25	8.00	8.23	8.54
1857	8.00	8.04	8.03	8.02	7.98	8.00	8.00	8.00	8.00	8.00	8.00	8.00	8.01
1858	8.00	8.00	8.35	9.12	8.50	8.67	8.50	8.80	9.00	9.00	8.50	8.44	8.57

REMARKS.—The readings give the depth of water on the miter sill of lower lock, taken about four times a month, and the average taken as a monthly mean.

From a comparison of the mean of the means of six years between Kingston and Port Dalhousie, the miter sill at Kingston Mills is 233.12 + 13.35 — 8.45, or 238.02 feet above mean tide at New York.

The value used for this miter sill, 237.81, deduced from a comparison of water levels, 1893 to 1895, inclusive. (See Water levels for the Great Lakes, etc.)

The following is from an article by Maj. R. Lachlan, in American Journal of Science, vols. 69 and 70, 1855.

In contrast to Lake Erie from 1846 to 1852, Lake Ontario was as follows at mouth of Genesee River. Distances are from top of dock to water:

Year.	Distances.	Year.	Distances.
	Feet.		*Feet.*
1846	2.25	1849	1.75
1847	1.08	1850	1.42
1848	2.08	1851	1.92

NOTES.—In 1852 Lake Ontario 1.17 feet higher than in 1851. In 1853 Lake Ontario 0.75 foot higher, and calculated to be the same as in 1830 and 1838, and 4.42 feet feet above minimum of 1849. In 1838 Lake Ontario said to be 6 feet 10 inches above 1825.

LAKE ONTARIO.

[From article by Charles Whittlesey in Smithsonian Contributions to Knowledge, Vol. XII, 1860. This record is reduced from original Oswego records, but contains many readings not in any original table at hand.]

Year.a	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Mean.
1837	.....	.....	.....	.....	.....	.....	4.50	.....	.....	5.08	.....	.....	.....
1838	.....	.....	.....	.....	.....	.....	3.04	.....	3.98	4.42	.....	.....	.....
1839	5.46	.....	.....	.....	.....	.....	4.42	4.46	4.83	5.37	5.75	.....	.....
1840	.....	6.29	5.67	5.17	4.46	4.12	4.17	4.42	4.95	.....	5.49	5.68	.....
1841	5.69	5.79	5.96	5.23	4.54	4.56	4.71	5.12	.....	6.25	6.97	7.00	.....
1842	6.75	6.46	6.17	5.89	.....	5.42	5.23	5.58	5.75	6.10	6.35	6.55	.....
1843	6.45	.....	6.10	6.50	5.26	5.05	5.08	5.56	6.04	6.12	6.21	6.42	.....
1844	6.58	6.58	6.38	6.13	.....	5.25	5.23	5.39	5.52	6.46	.....	.....	.....
1845	6.60	6.37	.....	5.08	.....	5.08	5.42	5.88	6.50	6.42	6.79	.....	.....
1846	7.46	7.58	7.73	6.58	6.33	6.35	6.08	6.33	6.69	7.12	7.46	6.58	.....

a At Oswego, 1837 to 1845 inclusive, and at Oswego and Rochester, 1846.

REMARKS.—Record taken at Oswego by Lieutenant Smeed, U. S. A., from 1837 to 1840, and by J. W. Judson, C. E., from 1840 to 1845.

As the original record of Mr. Judson does not show nearly as full as this table, Mr. Whittlesey probably had access to other data which are not at hand in the original form. Mr. Whittlesey's reduced table is therefore inserted here.

The zero was the top of coping of the west pier near its southern end at the boat-house, counting downward to the surface of the water. This zero is stated to be the same as bench mark A. Oswego, elevation equals 251.96 feet. (Authority of William Pierson Judson.)

By a comparison of twenty months common to both registers, Mr. Spencer's or Professor Dewey's zero, or top of Rochester dock is 2.83 feet below Oswego zero, or elevation is 251.96—2.83=249.13 feet.

In 1795 yearly change of levels equals 3 feet by Mr. Weld (Weld's Travels in Canada). Lake reported higher than for the past thirty years. Lowest state since 1838 was November, 1848.

The following is from United States Lake Survey (Report of Chief of Engineers, 1876), plane of reference being high water of 1838. Elevation taken as 249.04 feet:

Locality.	Year.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
Oswego	1859	.....	.....	.....	.....	.....	0.12	0.46	0.64	1.15	1.64	2.23	2.24
Charlotte	1859	.....	.....	.....	.....	.....	0.15	0.46	0.96	1.66	2.13	2.62	2.29
Fort Niagara	1859	.....	.....	.....	.....	.....	0.56	0.79	1.08	1.73	2.32	2.74	2.52

The following is from New York Meteorology, by F. B. Hough. Measurements made by Deputy Harbor Master Smith, of Toronto. Published in Canadian Year Book for 1871 and given as upward from an arbitrary point. In this table the measurements have been reduced to read from a point 4.37 feet above the original zero, and the readings are all down to water surface. For six years, 1854–1859, the mean at Toronto was 2.06 and at Charlotte 2.31 feet, the former above and the latter below. The sum of the two equals 4.37 feet.

[Table prepared by Prof. G. T. Kingston, director observatory.]

Year.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Mean.
1854	2.71	2.62	2.54	2.35	1.60	1.39	1.52	2.10	2.50	2.92	3.48	3.62	2.44
1855	3.70	3.81	3.97	3.85	3.00	2.68	2.15	2.00	2.20	2.31	2.52	2.46	2.89
1856	2.73	2.87	2.95	2.66	1.97	1.69	1.86	2.22	2.60	2.99	3.50	3.75	2.65
1857	4.05	3.95	3.40	2.91	1.91	1.35	0.89	0.92	1.12	1.58	1.64	1.25	2.08
1858	1.77	1.87	2.34	2.00	1.83	1.09	0.82	0.99	1.59	1.96	2.29	2.64	1.77
1859	2.61	2.54	2.44	1.50	0.91	0.91	1.14	1.40	2.03	2.50	3.05	2.85	1.99

EXHIBIT C.

THE ICE SEASON.—BASIN OF THE GREAT LAKES AND SURROUNDING TERRITORY.[1]

[Longitude, 70° to 109° west; latitude, 37° to 59° north.]

SIR: In submitting this report on the data of the ice season of the United States and Canada, I call attention to the fact that an effort was first made to secure data upon the subject from governmental departments, where such data would be expected to be found, and it was ascertained that very little had been collected, and consequently only a small amount of the data found in the United States tables were furnished.

The department of public works of Canada had much more data on record, and it was willingly furnished for the compiling of the tables for Canadian points along the Great Lakes.

An original collection of data was begun by order of the engineer of the Commission, and a voluminous correspondence was undertaken with heads of departments of public works, observers of weather bureaus, directors of meteorological offices, superintendents of marine and fisheries departments, inspectors of light-house establishments, light-house keepers, collectors of customs, boat captains, ice merchants, city engineers, postmasters, secretaries of boards of trade, and lake carriers' association, managers and superintendents of railroad companies, managers of steamboat lines and ferries, and private individuals, and others in the United States and Dominion of Canada who were in position to have the information sought.

A commendable interest was awakened among officials and private citizens on the subject, and a great amount of data was furnished, either directly or indirectly, covering 171 points and 26 canals, situated in both countries.

This data represents a vast amount of research among old documents, diaries, log books, and books of accounts. The data as received were arranged in a very miscellaneous manner and has been systematically compiled in tables, and where examined and compared has been found to be very consistent.

The data for some points were difficult to obtain and involved an extended inquiry before the proper party could be found; but eventually some person was discovered who could furnish the data, which in several instances covered a long period. Had more time been available it would doubtless have been possible to discover the existence of data at other points and obtain the same.

[1] Prepared under the direction of L. E. Cooley, C. E., by Assistant Charles Poore.

More than 700 letters have been sent out for information, and, with but few exceptions, replies have been received, saying the writers would gladly do what they could to obtain the information sought. And when it could not be readily discovered it required time to locate the party having the information, and the time allotted for this investigation has proved too short to obtain all data that should be embodied in this report.

In this connection the great interest taken and the spirit of cooperation exhibited is to be especially commended, and to it is due in large part whatever success the investigation has attained.

Accompanying this report are 183 tables, 150 of them giving data of ice closings for different places, 26 giving the official closing and opening of canals, and 7 uncompleted tables for different points.

The authority from whom the data were obtained is noted under each table along with other items of interest.

The latitude north and longitude west with the altitude as far as obtainable are found at the top.

The tables give the year and date of the opening and closing, and at the foot the average date of opening and average date of closing and average number of days closed.

Dates found inclosed in parentheses are interpolated, and are found as follows: An arbitrary is obtained by comparing the dates for identical years in some other table of near latitude, and this is applied with its proper algebraic sign, and the new date thus obtained is inserted in the blank space. The method in detail is as follows:

Compare dates in uncompleted table with dates of completed table, selected as the basis for same period. Note the difference, with its proper algebraic sign, between dates, continue this process over as long a period as possible, using only one column at a time; combine these differences algebraically and divide the result by the number of years used. The quotient, with its proper algebraic sign, is the arbitrary to apply to the dates in the basis table to obtain the dates to be interpolated.

These interpolated dates are used in obtaining the average closing and opening and average number of days closed for equivalent periods.

The average dates of opening and closing, and the average number of days closed, are given at the foot of the table for as long a period as the tables will permit.

The larger proportion of the tables are actual ice record, some of the remainder are first and last vessel, and others official opening and closing. These differences are clearly noted on the diagrams accompanying this report.

A general index table arranged in alphabetical order accompanies this report. This is a summary of the data, and gives the number of the tables, the latitude north, longitude west, and the altitude as far as obtainable, the average date of closing, the average date of opening, the character of data, the number of years used for securing averages, and the average number of days closed. There is also added the twenty years' period from the winter of 1876–77 to the winter of 1895–96, inclusive, showing average closing, the average opening, and the average number of days closed. In this table will also be found miscellaneous notes giving name of place, the latitude north, the longitude west, the altitude as far as obtainable, the estimated closing, the estimated opening, the estimated number of days closed, and the authority.

DIAGRAM SHEETS.

In connection with this report are submitted five sheets of diagrams marked "ice season," and numbered from 1 to 5, inclusive. These cover in detail only such portions of the data as pertains to points about the Great Lakes, the St. Lawrence and Hudson rivers, and to various routes under consideration.

No. 1 exhibits in the first column the average dates of closing and opening (twenty years period) and diagrams of the ice season at points which govern the routes designated.

The second column contains the diagrams of the average number of days closed at the different places specified during the period from the winter of 1876–77 to the winter of 1895–96, inclusive.

The third column contains diagrams of the average number of days closed at different points on the rivers for the same period.

The fourth column contains diagrams of the "canal closing season" covering the periods given in the tables. In this column will also be found miscellaneous notes giving diagrams of the estimated number of days closed of several points not tabulated.

On account of the short time available, estimated data only could be obtained at some remote points, and at others parties are still endeavoring to obtain the data.

No. 2 displays detailed diagrams of the data obtained and exhibited in the tables and the diagram of the average number of days closed for the period mentioned. These diagrams apply to places on or near Lake Huron, Lake Michigan, and Lake Superior.

No. 3 displays detailed diagrams of the data obtained and exhibited in the tables and the diagram of the average number of days closed for the period mentioned. These diagrams apply to places on or near Lake Erie and Lake St. Clair.

No. 4 displays detailed diagrams of the data obtained and exhibited in the tables, and the diagram of the average number of days closed for the period mentioned. These diagrams apply to places on and near Lake Ontario and Lake Oneida.

No. 5 displays detailed diagrams of the data obtained and exhibited in the tables, and the diagram of the average number of days closed for the period mentioned. These diagrams apply to places on or near to Lake Champlain, St. Lawrence, Hudson, Connecticut, and Merrimac rivers. In completing diagrams the same method of finishing ends is adopted as used on Sheet No. 1, with this exception—one end being discontinued with considerable slant, indicates that the data for that end could not as yet be obtained. Where years are left entirely blank, no dates could be obtained.

Space has been left at the top so that diagrams of the remaining years of the century may be added. As most of the data of the ice season submitted is the original compilation, and the time allowed for the investigation was limited, a thorough checking could not be made, and dates subsequently gathered upon more extensive research may cause slight changes.

Much new data may be added which will be of great interest and from which more reliable conclusions could be obtained, and some valuable laws may, without doubt, be deduced.

Respectfully submitted.

CHARLES POORE, C. E.,
Assistant.

Mr. L. E. COOLEY, C. E.,
Engineer United States Deep Waterways Commission.

General index table—Ice season.

Location.	Latitude north	Longitude west.	Altitude.	Table. No.	Table. Average dates. Closing.	Table. Average dates. Opening.	Table. Character of data.	Table. Years used for averages.	Table. Number of days closed.	Winter of 1876-77 to winter of 1895-96 inclusive. Average dates. Closing.	Winter of 1876-77 to winter of 1895-96 inclusive. Average dates. Opening.	Winter of 1876-77 to winter of 1895-96 inclusive. Number of days closed.
	° ′	° ′	*Feet.*									
Amoskeag, N. H	42 59	71 29	.....	1	Nov. 28	Mar. 19	Ice.....	18	111	(Dec. 30)	(Mar. 19)	(110)
Albany, N. Y	42 39	73 45	1.30	2	Dec. 15	Mar. 20	Ice.....	87	95	Dec. 22	Mar. 26	94
Alpena, Mich	45 06	83 30	579.60	3	Dec. 19	Apr. 6	Ice.....	18	108	Dec. 18	Apr. 6	109
Ashand, Wis	46 36	90 53	600.69	4	Dec. 1	Apr. 25	Ice.....	11	145	(Dec. 6)	(Apr. 24)	139
Bell Island light-house, Mich	42 20	82 58	.....	5	Dec. 20	Apr. 3	Ice.....	14	104	(Dec. 21)	(Apr. 5)	(105)
Belleville, Ontario	44 10	77 23	244.53	6	Dec. 2	Apr. 12	Ice.....	25	131	Dec. 3	Apr. 12	130
Bismarck, N. Dak	46 47	100 38	1,618.00	7	Nov. 25	Mar. 31	Ice.....	24	126	Nov. 23	Mar. 31	128
Brainerd, Minn	46 29	94 10	1,150.00	8	Nov. 20	Apr. 17	Ice.....	20	149	Nov. 20	Apr. 17	149
Brewerton, N. Y	43 14	76 11	369.00	9	Dec. 13	Apr. 9	Ice.....	22	117	Dec. 9	Apr. 3	115
Buffalo, N. Y	42 53	78 53	571.00	10	Dec. 12	Apr. 9	Ice.....	20	118	Dec. 12	Apr. 9	118
Cairo (Missippi River), Ill	37 00	89 10	279.00	11	Jan. 9	Feb. 5	Ice.....	22	27	Jan. 9	Feb. 4	26
Cairo (Ohio River), Ill	37 00	89 10	279.00	12	Jan. 26	Feb. 3	Ice.....	21	8	Jan. 21	Jan. 29	8
Campbellton, New Brunswick	48 01	66 40	.....	13	Dec. 6	May 1	Official....	23	146	Dec. 6	May 1	146
Cape Vincent, N. Y	43 51	76 19	244.53	14	Dec. 20	Apr. 10	Ice.....	20	111	Dec. 19	Apr. 9	111
Cazenovia, N. Y	42 56	75 54	1,177.00	15	Dec. 13	Apr. 12	Ice.....	51	120	Dec. 6	Apr. 4	119
Charity Island light-house, Mich	44 02	83 26	579.60	16	Dec. 17	Apr. 6	Ice.....	22	110	Dec. 18	Apr. 5	108
Charleston, W. Va	38 21	81 35	1,619.00	17	Jan. 20	Jan. 28	Ice.....	24	8	Jan. 12	Jan. 20	8
Charlottetown, Prince Edward Island	46 14	63 07	.....	18	Dec. 23	Apr. 15	Official....	29	113	Dec. 28	Apr. 16	109
Cheboygan light-house, Mich	45 40	84 25	579.60	19	Dec. 17	Apr. 11	Ice.....	16	115	(Dec. 18)	(Apr. 11)	(114)
Cherry Island light-house, Quebec	.....	.....	.....	20	Nov. 30	Apr. 27	Official....	34	148	Nov. 29	Apr. 27	149
Chicago, Ill	41 53	87 37	.....	21	Jan. 7	Feb. 27	Ice.....	25	51	(Jan. 10)	(Feb. 24)	(45)
Cincinnati, Ohio	39 06	84 30	431.00	22	Jan. 15	Jan. 25	Ice.....	39	10	Jan. 15	Jan. 26	11
Cleveland, Ohio	41 30	87 42	571.35	23	Dec. 23	Mar. 23	Ice.....	25	90	Dec. 23	Mar. 24	91
Collingswood, Ontario	44 31	80 02	579.60	24	Dec. 2	Apr. 25	Ice.....	29	144	Dec. 3	Apr. 24	142
Constantia, N. Y	43 17	76 03	369.00	25	Dec. 16	Apr. 5	Ice.....	51	110	Dec. 16	Apr. 7	112
Caponaning, Ontario	46 00	80 45	579.60	26	Dec. 3	Apr. 25	Ice.....	19	143	(Dec. 2)	(Apr. 27)	(143)
Davenport, Iowa	41 30	90 38	541.00	27	Dec. 12	Mar. 19	Ice.....	25	97	Dec. 13	Mar. 19	96
Des Moines Rapids, Iowa	40 61	91 25	500.00	28	Jan. 3	Feb. 20	Ice.....	20	48	Jan. 3	Feb. 23	48
Detour light-house, Mich	45 59	83 54	579.60	29	Dec. 9	Apr. 13	Ice.....	22	125	Dec. 8	Apr. 11	124
Detroit River, Mich	42 20	83 03	573.84	30	Dec. 17	Mar. 20	Ice.....	22	93	Dec. 18	Mar. 21	93
Duboistown, Pa	41 14	77 08	.....	31	Dec. 30	Feb. 12	Ice.....	11	44	(Jan. 6)	(Feb. 14)	(39)
Dubuque, Iowa	42 30	90 44	585.00	32	Nov. 26	Mar. 21	Ice.....	25	115	Nov. 27	Mar. 18	111
Duluth, Minn	46 47	92 06	600.69	33	Dec. 6	Apr. 24	Ice.....	39	139	Dec. 14	Apr. 24	131
Eagle Bluff light-house, Wis	45 10	87 14	579.60	34	Dec. 20	Apr. 14	Ice.....	9	115	(Dec. 11)	(Apr. 16)	(126)
Erie, Pa	42 07	80 05	571.35	35	Dec. 21	Apr. 8	Ice.....	23	108	Dec. 23	Apr. 8	106
Escanaba, Mich	45 48	87 05	579.60	36	Dec. 6	Apr. 20	Ice.....	25	135	Dec. 8	Apr. 18	131
Fort Benton, Mont	47 48	110 46	2,565.00	37	Jan. 3	Feb. 27	Ice.....	5	53	(Jan. 10)	(Feb. 26)	(47)

Fort Buford, N. Dak	48	02	104	01	1,855.00	38	Nov. 13	Apr. 13	Ice	15	151	(Nov. 10)	(Apr. 9)	(150)
Fort Custer, Mont	45	46	107	48	2,727.00	39	(Dec. 9)	(Mar. 18)	Ice	(20)	(99)	(Dec. 9)	(Mar. 18)	(99)
Fort Gratiot light-house, Mich	43	00	82	25	579.60	40	Dec. 19	Apr. 6	Ice	22	108	Dec. 22	Apr. 8	107
Georgetown, Prince Edward Island	46	11	62	35	.....	41	Jan. 26	Apr. 10	First and last vessel.	23	74	Jan. 27	Apr. 8	71
Goderich, Ontario	43	45	81	33	579.60	42	Dec. 4	Apr. 16	Ice	29	133	Dec. 7	Apr. 13	127
Grand Forks, N. Dak	47	55	97	01	784.00	43	Nov. 8	Apr. 15	Ice	7	158	.....	.....	.....
Grand Haven, Mich	43	05	86	13	579.60	44	Feb. 4	Feb. 18	Ice	28	14	Feb. 5	Feb. 16	11
Grand Island light-house, Mich	46	34	86	41	600.69	45	Dec. 1	Apr. 30	Ice	22	150	Dec. 1	Apr. 28	148
Grand Marais light-house, Minn	47	44	90	20	600.69	46	Dec. 13	Apr. 19	Ice	11	127	(Dec. 17)	(Apr. 18)	(122)
Grand Rapids, Mich	42	59	85	50	586.60	47	Nov. 29	Mar. 22	Ice	28	113	Dec. 2	Mar. 21	109
Grand Traverse light-house, Mich	45	12	85	34	579.60	48	Dec. 21	Apr. 3	Ice	9	103	(Dec. 23)	(Apr. 2)	(100)
Green Bay, Wis	44	31	88	00	579.60	49	Dec. 6	Apr. 15	Ice	22	130	Dec. 7	Apr. 14	128
Green Island light-house, Wis	45	03	87	29	579.60	50	Dec. 29	Apr. 9	Ice	9	101	(Dec. 22)	(Apr. 9)	(108)
Grosse Pointe light-house, Quebec	.....	.....	.....	.....	153.50	51	Dec. 2	Apr. 29	Official	23	148	Dec. 3	Apr. 20	147
Hamilton Island light-house, Ontario	.....	.....	.....	.....	153.50	52	Nov. 30	Apr. 28	Official	23	149	Nov. 28	Apr. 27	150
Harrisburg, Pa	40	16	76	52	289.96	53	Jan. 18	Feb. 14	Ice	26	27	Jan. 13	Feb. 11	29
Hartford, Conn	41	45	72	39	0.00	54	Dec. 12	Mar. 12	Ice	42	90	Dec. 17	Mar. 7	80
Hennepin, Ill	41	15	89	22	438.61	55	Nov. 28	Mar. 8	Ice	16	100	(Dec. 1)	(Mar. 4)	(93)
Jefferson City, Mo	38	36	92	14	523.00	56	Jan. 11	Feb. 2	Ice	13	22	(Jan. 11)	(Feb. 6)	(26)
Kansas City, Mo	39	05	94	37	716.00	57	Jan. 5	Feb. 12	Ice	22	38	Dec. 25	Feb. 1	38
Keokuk, Iowa	40	22	91	26	477.00	58	Jan. 5	Feb. 25	Ice	26	51	Jan. 8	Feb. 26	49
Kincardine, Ontario	44	10	81	37	579.60	59	Nov. 21	Apr. 15	Official	21	145	Nov. 21	Apr. 14	144
Kingston, Ontario	44	15	76	29	244.53	60	Jan. 2	Apr. 8	Ice	64	96	Jan. 2	Apr. 7	95
La Crosse, Wis	43	49	91	15	628.00	61	Dec. 5	Mar. 26	Ice	25	111	Dec. 7	Mar. 24	107
Lake Champlain, Burlington, Vt	44	30	73	14	95.03	62	Jan. 26	Apr. 1	Ice	81	64	Jan. 20	Mar. 24	63
Lake Pepin, Minn	44	30	92	26	.....	63	Nov. 25	Apr. 12	Ice	35	138	Nov. 23	Apr. 9	137
Lake Simcoe, Ontario	44	23	78	43	714.00	64	Dec. 22	Apr. 24	Ice	41	123	Dec. 25	Apr. 22	118
Lake St. Francis, Ontario	.....	.....	.....	.....	153.50	65	Dec. 24	Apr. 12	Ice	4	109	(Dec. 23)	(Apr. 14)	(112)
Lancaster Pier light-house, Ontario	.....	.....	.....	.....	.....	66	Dec. 1	Apr. 27	Official	34	147	Nov. 30	Apr. 27	148
Leavenworth, Kans	39	18	94	57	742.00	67	Jan. 7	Feb. 18	Ice	22	42	Jan. 1	Feb. 12	42
Little Traverse light-house, Mich	45	25	84	58	579.60	68	Dec. 15	Apr. 14	Ice	9	120	(Dec. 21)	(Apr. 13)	(113)
Long Tail Point light-house, Wis	44	36	87	59	579.60	69	Dec. 5	Apr. 10	Ice	9	126	(Dec. 10)	(Apr. 10)	(121)
Louisville, Ky	38	15	85	45	394.45	70	Could not be obt'n'd		Ice	50	12	Could not be obt'n'd		16
Mackinaw City, Mich	45	52	84	52	579.60	71	Dec. 31	Apr. 15	Ice	18	105	(Jan. 2)	(Apr. 13)	(101)
Mankato, Minn	44	08	94	00	756.00	72	Nov. 27	Apr. 6	Ice	41	130	Nov. 29	Apr. 5	127
Marquette light-house, Mich	46	33	87	22	600.69	73	Dec. 10	Apr. 27	Ice	22	138	Dec. 9	Apr. 25	137
Marquette, Mich	46	34	87	24	600.69	74	Nov. 28	May 3	First and last vessel.	25	156	Nov. 25	Apr. 30	151
Menominee light-house, Mich	45	06	87	35	579.60	75	Dec. 28	Apr. 14	Ice	9	107	(Dec. 20)	(Apr. 13)	(114)
Meredosia, Ill	39	49	90	37	424.31	76	Dec. 7	Feb. 19	Ice	9	74	(Dec. 16)	(Feb. 18)	(64)
Milwaukee, Wis	43	02	87	54	579.60	77	Feb. 24	Mar. 10	Ice	24	14	Feb. 22	Mar. 10	16
Mission Point light-house, Mich	44	59	85	28	579.60	78	Dec. 17	Apr. 5	Ice	9	109	(Dec. 17)	(Apr. 6)	(110)
Monroe, Mich	41	52	83	16	571.35	79	Dec. 13	Mar. 7	Ice	20	84	Dec. 13	Mar. 7	84
Montreal, Quebec	45	31	73	33	23.00	80	Dec. 13	Apr. 20	Ice	48	128	Dec. 10	Apr. 19	130
Moorhead, Minn	46	52	96	44	866.00	81	Nov. 14	Apr. 18	Ice	7	155	(Nov. 17)	(Apr. 17)	(150)
Morris, Ill	41	21	88	25	479.63	82	Jan. 6	Mar. 10	Ice	6	63	(Jan. 9)	(Feb. 28)	(50)
Nebraska City, Nebr	40	40	95	51	907.00	83	Dec. 14	Feb. 27	Ice	33	75	Dec. 21	Mar. 1	70

General index table—Ice season—Continued.

Location.	Latitude north.	Longitude west.	Altitude.	Table. No.	Table. Average dates. Closing.	Table. Average dates. Opening.	Table. Character of data.	Table. Years used for averages.	Table. Number of days closed.	Winter of 1876–77 to winter of 1895–96 inclusive. Average dates. Closing.	Winter of 1876–77 to winter of 1895–96 inclusive. Average dates. Opening.	Winter of 1876–77 to winter of 1895–96 inclusive. Number of days closed.
	° ′	° ′	*Feet.*									
Ogdensburg, N. Y	44 43	75 30	244.28	84	Dec. 15	Apr. 10	Ice	55	116	Dec. 15	Apr. 6	112
Omaha, Nebr	41 16	95 56	960.00	85	Dec. 14	Mar. 16	Ice	23	92	Dec. 16	Mar. 14	88
Oshkosh, Wis	44 02	88 32	750.00	86	Nov. 22	Apr. 14	First and last vessel.	20	143	Nov. 22	Apr. 14	143
Oswego, N. Y	43 29	76 35	244.53	87	Dec. 17	Apr. 4	do	36	108	Dec. 19	Apr. 4	106
Ottawa, Ontario	45 16	75 42	131.00	88	Nov. 26	Apr. 25	Ice	50	150	Nov. 25	Apr. 26	152
Otsego Lake, N. Y	42 50	74 54	1,300.00	89	Jan. 7	Apr. 17	Ice	46	100	Jan. 9	Apr. 16	97
Outer Island light-house, Wis	46 56	90 25	600.69	90	Nov. 27	May 3	Official	22	157	Nov. 25	May 1	156
Owen Sound, Ontario	44 34	80 55	579.60	91	Dec. 6	Apr. 19	Ice	29	134	Dec. 3	Apr. 16	134
Passage Island light-house, Lake Superior	48 14	88 22	600.69	92	Nov. 19	May 5	Official	13	167	(Nov. 23)	(Apr. 30)	(158)
Pearl, Ill	39 28	90 38	411.11	93	Dec. 26	Feb. 10	Ice	17	46	(Dec. 28)	(Feb. 9)	(43)
Peoria, Ill	40 41	89 37	432.00	94	Dec. 17	Feb. 21	Ice	53	66	(Dec. 21)	(Feb. 28)	(60)
Percé, Quebec	48 31	64 13	.....	95	Nov. 29	Apr. 25	Official	29	147	Dec. 4	Apr. 19	136
Pictou, Nova Scotia	45 41	62 42	.....	96	Dec. 25	Apr. 12	Official	26	108	Dec. 27	Apr. 11	105
Pierre, S. Dak	44 24	100 17	1,426.00	97	Nov. 28	Mar. 30	Ice	16	122	(Nov. 22)	(Apr. 2)	(131)
Pittsburg, Pa	40 32	80 02	699.00	98	Jan. 27	Jan. 29	Ice	27	2	Jan. 27	Jan. 29	2
Point Pleasant, W. Va	38 53	82 10	510.00	99	Jan. 6	Jan. 18	Ice	19	12	(Jan. 11)	(Jan. 17)	(6)
Port Arthur, Ontario	48 24	89 28	600.69	100	Dec. 21	May 1	Ice	23	131	Dec. 23	May 1	129
Port Austin light-house, Mich	44 05	82 58	579.60	101	Dec. 17	Apr. 6	Ice	17	110	(Dec. 16)	(Apr. 7)	(112)
Port Dover, Ontario	42 47	80 13	571.35	102	Dec. 4	Apr. 15	Ice	29	132	Dec. 4	Apr. 12	129
Port Hope, Ontario	43 56	78 15	244.53	103	Dec. 15	Apr. 3	Ice	29	109	Dec. 18	Apr. 4	107
Port Huron, Mich	43 00	82 26	579.60	104	Dec. 11	Apr. 4	Ice	25	114	Dec. 12	Apr. 3	112
Port Stanley, Ontario	42 40	81 13	571.35	105	Dec. 18	Mar. 30	Ice	29	102	Dec. 22	Mar. 29	97
Portage River light-house, Mich	46 59	88 24	600.69	106	Dec. 3	Apr. 25	Ice	22	143	Dec. 7	Apr. 24	138
Porte des Morts light-house, Wis	45 17	86 55	579.60	107	Dec. 24	Apr. 10	Ice	9	107	(Dec. 17)	(Apr. 9)	(113)
Poverty Island light-house, Mich	45 31	86 40	579.60	108	Dec. 8	Apr. 13	Official	9	126	(Dec. 9)	(Apr. 14)	(126)
Quebec, Province of Quebec	46 49	71 12	—6.11	109	Dec. 4	Apr. 21	Ice	61	138	Dec. 2	Apr. 20	139
Quincy, Ill	39 55	91 25	458.00	110	Dec. 13	Feb. 27	Ice	20	76	Dec. 13	Feb. 27	76
Rochester, N. Y	43 08	77 42	508.00	111	Dec. 9	Apr. 5	Ice	12	117	(Dec. 13)	(Apr. 6)	(114)
Rock Island, Ill	41 29	90 37	541.00	112	Dec. 28	Mar. 14	Ice	45	76	Dec. 25	Mar. 16	81
Rouse's Point, N. Y	44 59	73 22	95.03	113	Dec. 5	Apr. 17	Ice	19	133	Dec. 5	Apr. 17	133
Saginaw River light ranges, Mich	43 38	83 50	579.60	114	Dec. 10	Apr. 7	Ice	22	118	Dec. 17	Apr. 7	111
Saint Paul, Minn	44 58	93 03	683.00	115	Nov. 21	Apr. 13	Ice	41	143	Nov. 24	Apr. 12	139
Sand Beach light-house, Mich	43 51	82 37	579.60	116	Dec. 20	Apr. 3	Ice	17	104	(Dec. 20)	(Apr. 4)	(105)
Sandusky Bay, Mich	41 25	82 40	571.35	117	Dec. 19	Mar. 22	Ice	25	93	Dec. 21	Mar. 21	90
Sand Point light-house, Mich	46 47	88 28	600.69	118	Dec. 2	Apr. 27	Ice	17	146	(Dec. 4)	(Apr. 27)	(144)

Sarnia, Ontario	42	59	82	24	579.60	119	Dec. 24	Mar. 28	Ice	29	94	Dec. 28	Mar. 31	93
Sault Ste. Marie, Ontario	46	30	84	22	581.41	120	Dec. 2	Apr. 30	Ice	28	149	Dec. 3	Apr. 27	145
Seneca, Ill	41	14	88	37	479.63	121	Jan. 2	Feb. 21	Ice	42	50	(Jan. 2)	(Feb. 22)	(51)
Shediac, New Brunswick	46	15	64	32	.....	122	Dec. 8	Apr. 29	Official	19	142	(Dec. 8)	(Apr. 29)	(142)
Sioux City, Iowa	42	29	96	24	1,066.00	123	Dec. 17	Mar. 17	Ice	19	90	Dec. 17	Mar. 17	90
South Fox Island light-house	45	22	85	50	579.60	124	Dec. 12	Apr. 7	Ice	9	116	(Dec. 13)	(Apr. 7)	(115)
St. Charles, Mo	38	46	90	45	416.00	125	Jan. 10	Jan. 29	Ice	15	19	(Jan. 12)	(Jan. 31)	19
St. Clair Flats light-house, Mich	42	32	82	41	.....	126	Dec. 15	Apr. 4	Ice	22	110	Dec. 17	Apr. 5	109
St. Croix River, Wis	44	55	92	45	667.00	127	Nov. 20	Apr. 9	Ice	33	140	Nov. 22	Apr. 11	140
St. Joseph, Mo	39	45	94	52	790.00	128	Dec. 19	Feb. 19	Ice	18	62	(Dec. 18)	Feb. 17)	61
St. Louis, Mo	38	38	90	12	384.00	129	...do	Jan. 20	Ice	31	32	Dec. 17	Jan. 26	30
St. Marys Falls light-house, Mich	46	30	84	23	.....	130	Dec. 2	Apr. 27	Ice	22	146	Dec. 3	Apr. 26	144
St. Vincent, Minn	48	56	97	14	748.00	131	Nov. 10	Apr. 18	Ice	21	159	(Nov. 12)	(Apr. 17)	(156)
Straits of Mackinac, Mich	45	43	84	46	579.60	132	Jan. 9	Apr. 17	Ice	16	98	(Jan. 6)	(Apr. 15)	(99)
Sturgeon Point light-house, Mich	44	47	83	15	579.60	133	Dec. 18	Apr. 2	Ice	22	105	Dec. 18	Apr. 1	104
Sydney, Nova Scotia	46	09	60	13	.....	134	Jan. 13	Apr. 22	First and last vessel	22	99	Jan. 12	Apr. 21	99
Sherwood Point light-house, Wis	44	53	87	26	579.60	135	Dec. 27	Apr. 10	Ice	9	104	(Dec. 28)	(Apr. 13)	(106)
Tawas light-house, Mich	44	15	83	27	579.60	136	Dec. 18	Apr. 2	Ice	22	105	Dec. 18	Apr. 1	104
Terre Haute, Ind	39	27	87	24	447.00	137	Dec. 14	Feb. 16	Ice	13	64	.....	.....	.....
The Arsenal, Central Park, New York City	40	45	73	56	.....	138	Jan. 5	Feb. 15	Ice	35	41	Jan. 15	Feb. 11	29
Thunder Bay Island light-house, Mich	45	02	83	11	579.60	139	Dec. 14	Apr. 5	Ice	22	112	Dec. 14	Apr. 4	111
Toledo, Ohio	41	40	83	34	571.35	140	Dec. 10	Apr. 1	Ice	25	112	Dec. 16	Mar. 31	105
Toronto, Ontario	43	38	79	29	244.53	141	Dec. 19	Mar. 21	Ice	53	92	Dec. 21	Mar. 25	94
Turners Falls, Mass	42	34	72	34	.....	142	Dec. 9	Mar. 16	Ice	12	97	(Dec. 6)	(Mar. 14)	(98)
Wagoshance light-house, Mich	45	47	85	05	579.60	143	Dec. 12	Apr. 9	Ice	9	118	(Dec. 13)	(Apr. 9)	(117)
Whitehall, N. Y	43	34	73	24	95.03	144	Dec. 17	Apr. 11	Ice	35	115	Dec. 25	Apr. 6	102
Windmill Point light-house, Mich	42	21	82	56	.....	145	Dec. 21	Apr. 2	Ice	22	102	Dec. 20	Apr. 1	102
Windsor, Ontario	42	19	83	02	573.86	146	Dec. 16	Feb. 26	Ice	28	72	Jan. 13	Mar. 14	60
Winnipeg, Manitoba	49	52	97	08	724.00	147	Nov. 8	Apr. 21	Ice	20	164	Nov. 8	Apr. 21	164
Yankton, S. Dak	42	54	97	28	1,150.00	148	Dec. 7	Mar. 21	Ice	22	104	Dec. 9	Mar. 20	101
York Factory, Keewatin	57	00	92	28	.....	149	Nov. 19	May 19	Ice	55	181	a Nov. 20	May 18	179
Zanesville, Ohio	39	59	82	00	678.00	150	Jan. 8	Feb. 25	Ice	8	53	.....	.....	.....
CANALS.														
Beauharnois, Quebec	.....		.....		.....	151	Dec. 3	Apr. 28	Official	51	146	.....	.....	.....
Carillon, Ontario	.....		.....		.....	152	Nov. 28	Apr. 30	Official	36	153	.....	.....	.....
Chambby, Quebec	.....		.....		.....	153	Nov. 29	May 1	Official	52	153	.....	.....	.....
Chesapeake and Ohio	.....		.....		.....	154	Dec. 23	Mar. 18	Official	5	85	.....	.....	.....
Champlain, N. Y	.....		.....		.....	155	Dec. 7	Apr. 28	Official	72	142	.....	.....	.....
Cornwall, Ontario	.....		.....		.....	156	Dec. 3	Apr. 27	Official	53	145	.....	.....	.....
Delaware and Hudson, N. Y	40	55	73	58	0.00	157	Dec. 5	Apr. 7	Official	25	123	.....	.....	.....
Delaware and Raritan, N. J	40	13	74	45	.....	158	Dec. 23	Mar. 15	Official	45	82	.....	.....	.....
Des Moines Rapids, Iowa	40	61	91	25	500.00	159	Nov. 21	Mar. 24	Official	19	123	.....	.....	.....
Erie, N. Y	.....		.....		.....	160	Dec. 5	Apr. 27	Official	72	143	.....	.....	.....
Farrans Point, Ontario	.....		.....		.....	161	Dec. 7	Apr. 27	Official	48	141	.....	.....	.....
Grenville, Ontario	.....		.....		.....	162	Nov. 28	May 1	Official	36	154	.....	.....	.....

a Winter of 1860–61 to the winter of 1879–80, inclusive.

General index table—Ice season—Continued.

Location.	Latitude north.	Longitude west.	Altitude.	Table. No.	Table. Average dates. Closing.	Table. Average dates. Opening.	Table. Character of data.	Table. Years used for averages.	Table. Number of days closed.	Winter of 1876-77 to winter of 1895-96 inclusive. Average dates. Closing.	Winter of 1876-77 to winter of 1895-96 inclusive. Average dates. Opening.	Winter of 1876-77 to winter of 1895-96 inclusive. Number of days closed.
	° ′	° ′	*Feet.*									
Illinois and Michigan, Ill				163	Nov. 24	Apr. 1	Official	45	128			
Lachine, Quebec				164	Dec. 2	Apr. 30	Official	61	149			
Portage Lake Ship, Mich	47 04	88 17	600.69	165	Nov. 27	May 1	Official	14	155			
Rapide Plat, Ontario				166	Dec. 7	Apr. 27	Official	48	141			
Rideau, Jones Falls, Ontario				167	Nov. 22	Apr. 29	Official	51	158			
Rideau, Kingston, Ontario				168	Nov. 28	May 1	Official	48	154			
Rideau, Ottawa, Ontario	45 16	75 42		169	Nov. 25	Apr. 30	Official	64	156			
St. Anne's Lock, etc				170	Nov. 29	Apr. 25	Official	53	147			
Sault Ste. Marie, Mich	46 28	84 22	600.05	171	Dec. 3	Apr. 25	Official	42	143			
St. Ours Lock, Quebec				172	Nov. 30	Apr. 16	Official	46	137			
St. Peters				173	Dec. 31	Apr. 22	Official	13	112			
The Galops, Ontario				174	Dec. 7	Apr. 27	Official	47	141			
Trent River, Ontario				175	Nov. 22	Apr. 17	Official	29	146			
Welland, Ontario				176	Dec. 10	Apr. 17	Official	53	128			
MISCELLANEOUS NOTES.											*Authority.*	
Norway House, Keewatin	53 40	98 00	702.00	.....	Nov. 26	June 1	Estimated	.....	187		Mr. C. C. Chipman.	
Oxford Lake, Keewatin	55 02	95 16		.....	Nov. 1	June 4	Estimated	.....	215		Mr. C. C. Chipman.	
Battleford, Saskatchewan	52 45	108 30		.....	Nov. 29	Apr. 30	Estimated	.....	180		Mr. J. G. Oliver.	
Fort Churchill, Keewatin	58 52	95 00		.....	Nov. 15	June 15	Estimated	.....	212		Mr. J. B. Tyrell.	
Moose Fort, Ontario	51 16	80 56		.....	Nov. 13	May 9	Estimated	.....	177		Mr. Hugh V. Payne.	
Lake Nipissing, Ontario	46 16	79 45	642.00	.....	Nov. 29	May 3	Estimated	.....	155		Mr. H. C. Varin.	
Lake St. Johns, Ontario	48 25	71 35	293.00	.....	Dec. 1	May 10	Estimated	.....	160		Mr. G. F. Baillairge.	
Breckenridge, Minn	46 10	96 32	958.00	.....	Nov. 15	Apr. 15	Estimated	.....	151		Mr. E. Mattson.	
Ticonderoga, N. Y	43 51	73 23	95.00	.....	Dec. 9	Apr. 12	Estimated	.....	124		Mr. F. W. Baldwin.	
Allentown, Pa	40 38	75 33	221.00	.....	Dec. 31	Feb. 14	Estimated	.....	45		Mr. A. L. Richenbad.	
Lynchburg, Va	37 12	79 06	523.00	.....	Dec. 8	Jan. 0	Estimated	.....	29		Mr. L. F. Lucado.	

ADDENDA.

Since completing this report additional data have been received, and they have been compiled in tables marked and numbered A No. 1 to A No. 5, inclusive; also two tables added to the miscellaneous list, marked and numbered M No. 8 and M No. 9.

CHARLES POORE, C. E.

THE ICE SEASON.

No. 1.—AMOSKEAG (N. H.) GATEHOUSE, MERRIMAC RIVER.

[42° 59′ latitude north. 71° 29′ longitude west.]

Year.	Opened.	Closed.	Year.	Opened.	Closed.	Year.	Opened.	Closed.
1878	Mar. 11	Dec. 8	1887	Apr. 10	Dec. 2	1892	Jan. 15	Jan. 17
1879	Apr. 9	Dec. 18	1888	Apr. 7	Nov. 20	1892	Jan. 19	Jan. 26
1880	Mar. 5	Nov. 22	1888	Dec. 19	.....	1892	Mar. 29	Dec. 21
1881	Mar. 23	Nov. 26	1889	Mar. 11	Feb. 2	1893	Mar. 14	Nov. 27
1882	Mar. 22	Nov. 23	1889	.....	Dec. 5	1894	Mar. 6	Nov. 27
1883	Apr. 13	Dec. 3	1890	Mar. 24	Nov. 24	1895	Apr. 5	Dec. 13
1884	Mar. 28	Nov. 21	1891	Mar. 20	Dec. 1	1896	Mar. 2	.....
1885	Apr. 11	Nov. 27	1891	Dec. 28	.....			
1886	Mar. 31	Nov. 29	1892	.....	Jan. 6			

Average date of opening, March 19; average date of closing, November 28; average number of days closed, 111.

Authority: Mr. William E. Stearns.

NOTE.—Compared with Hartford, Conn., for interpolation for twenty years' period.

No. 2.—ALBANY, N. Y.—HUDSON RIVER.

[42° 39′ latitude north. Altitude, 1.30 feet. 73° 45′ longitude west.]

Year.	Opened.	Closed.	Year.	Opened.	Closed.	Year.	Opened.	Closed.
1645	.....	Nov. 24	1818	Mar. 25	Dec. 14	1858	Mar. 20	Dec. 18
1646	.....	Nov. 25	1819	Apr. 3	Dec. 13	1859	Mar. 13	Dec. 10
1676	Feb. 26	.....	1820	Mar. 25	Nov. 3	1860	Mar. 6	Dec. 14
1786	Mar. 23	.....	1821	Mar. 15	Dec. 13	1861	Mar. 5	Dec. 23
1790	Mar. 27	Feb. 3	1822	...do....	Dec. 24	1862	Apr. 4	Dec. 19
		Dec. 8	1823	Mar. 24	Dec. 16	1863	Apr. 3	Dec. 11
1791	Mar. 17	...do....	1824	Mar. 3	.....	1864	Mar. 11	Dec. 12
1792	.....	Dec. 12	1825	.....	Jan. 5	1865	Mar. 22	Dec. 16
1793	Mar. 6	Dec. 26	1825	Mar. 6	Dec. 13	1866	Mar. 20	Dec. 15
1794	Mar. 17	.....	1826	Feb. 26	Dec. 24	1867	Mar. 26	Dec. 8
1795	.....	Jan. 12	1827	Mar. 20	Dec. 25	1868	Mar. 24	Dec. 5
1795	.....	.....	1828	Feb. 8	Dec. 23	1869	Apr. 5	Dec. 9
1796	.....	Jan. 23	1829	Apr. 1	.....	1870	Mar. 31	Dec. 17
		Nov. 28	1830	.....	Jan. 11	1871	Mar. 13	Nov. 29
1797	.....	Nov. 26	1830	Mar. 15	Dec. 23	1872	Apr. 8	Dec. 10
1798	.....	Nov. 23	1831	...do....	Dec. 5	1873	Apr. 14	Nov. 26
1799	.....	.....	1832	Mar. 25	Dec. 21	1874	Mar. 21	Dec. 15
1800	.....	Jan. 6	1833	Mar. 21	Dec. 13	1875	Apr. 8	Dec. 1
1800	.....	.....	1834	Feb. 21	Dec. 15	1876	Apr. 1	Dec. 10
1801	.....	Jan. 3	1835	Mar. 25	Nov. 30	1877	Mar. 26	Dec. 29
1801	Feb. 28	.....	1836	Apr. 4	Dec. 7	1878	Mar. 7	Dec. 21
1802	.....	Feb. 3	1837	Mar. 28	Dec. 13	1879	Mar. 29	Dec. 21
1802	.....	Dec. 16	1838	Mar. 19	Nov. 25	1880	Mar. 1	Dec. 21
1803	.....	.....	1839	Mar. 21	Dec. 18	1881	Mar. 16	.....
1804	.....	Jan. 12	1840	Feb. 21	Dec. 5	1882	.....	Jan. 5
1804	Apr. 6	Dec. 13	1841	Mar. 24	Dec. 19	1882	Mar. 5	Dec. 4
1805	.....	.....	1842	Feb. 4	Nov. 29	1883	Mar. 31	Dec. 16
1806	.....	Jan. 9	1843	Apr. 13	Dec. 9	1884	Mar. 25	Dec. 19
1806	Feb. 20	Dec. 11	1844	Mar. 14	Dec. 11	1885	Apr. 8	Dec. 18
1807	Apr. 8	.....	1845	Feb. 24	Dec. 4	1886	Mar. 27	Dec. 6
1808	.....	Jan. 4	1846	Mar. 15	Dec. 15	1887	Apr. 6	Dec. 23
1808	Mar. 10	Dec. 9	1847	Apr. 6	Dec. 24	1888	Apr. 3	Dec. 12
1809	.....	.....	1848	Mar. 22	Dec. 27	1889	Mar. 19	Open.
1810	.....	Jan. 19	1849	Mar. 19	Dec. 25	1890	Open ...	Dec. 8
1810	.....	Dec. 14	1850	Mar. 9	Dec. 17	1891	Mar. 25	Dec. 20
1811	.....	Dec. 20	1851	Feb. 25	Dec. 13	1892	Apr. 28	Dec. 25
1812	.....	Dec. 21	1852	Mar. 28	Dec. 22	1893	Mar. 31	Dec. 11
1813	Mar. 12	Dec. 22	1853	Mar. 21	Dec. 21	1894	Mar. 17	Dec. 24
1814	.....	Dec. 10	1854	Mar. 17	Dec. 8	1895	Apr. 5	Dec. 9
1815	.....	Dec. 2	1855	Mar. 20	Dec. 20	1896	Apr. 7	.....
1816	.....	Dec. 16	1856	Apr. 10	Dec. 16			
1817	.....	Dec. 7	1857	Feb. 27	Dec. 27			

Average date of opening, March 20; average date of closing, December 15; average number of days closed, 95.

Authorities: New York Meteorology, 1850-1863, second series, by F. B. Hough; Mr. Horace Andrews, C. E.; Reports of Chief Signal Officer, United States Weather Bureau.

No. 3.—ALPENA, MICH.

[45° 05′ latitude north. Altitude, 579.6 feet. 83° 30′ longitude west.]

Year.	Opened.	Closed.	Year.	Opened.	Closed.	Year.	Opened.	Closed.
1871	Mar. 17	Dec. 10	1880	Mar. 6	Dec. 12	1888	Apr. 29	Dec. 20
1872	Apr. 17	Dec. 11	1881	Apr. 29	.....	1889	Apr. 5	.....
1873	Apr. 30	Dec. 5	1882	.....	Jan. 1	1890	.....	Jan. 16
1874	Mar. 20	Dec. 8*a*	1882	Mar. 6	Dec. 10	1890	Mar. 31	Dec. 8
1875	Apr. 19*b*	Dec. 14	1883	Apr. 19	Dec. 19	1891	Mar. 28	Dec. 22*a*
1876	Apr. 19	Dec. 9*a*	1884	Apr. 11	Dec. 17	1892	Apr. 6*b*	Dec. 11*a*
1877	Apr. 21*b*	.....	1885	Apr. 26	.....	1893	Apr. 2*b*	Dec. 3
1878	.....	Jan. 5	1886	.....	Jan. 8	1894	Mar. 13	Dec. 4*a*
1878	Mar. 10	Dec. 7*a*	1886	Apr. 15	Dec. 16	1895	Apr. 11*b*	Dec. 7*a*
1879	Apr. 5*b*	Dec. 12	1887	Apr. 18	Dec. 23	1896	Apr. 9*b*	.....

a Last boat. *b* First boat.

Average date of opening, April 6; average date of closing, December 19; average number of days closed, 108.

Authorities: United States Weather Bureau, 1896; Mr. J. C. Viall, Alpena Argus.

No. 4.—ASHLAND, WIS.

[46° 36′ latitude north. Altitude, 600.69 feet. 90° 53′ longitude west.]

Year.	Opened.	Closed.	Year.	Opened.	Closed.	Year.	Opened.	Closed.
1882	(Apr. 16)	(Dec. 21)	1887	May 5	Nov. 29	1892	Apr. 22	Nov. 23
1883	(Apr. 10)	(Dec. 15)	1888	May 1	Dec. 13	1893	May 9	Nov. 26
1884	(May 2)	(Dec. 16)	1889	Apr. 12	Dec. 5	1894	Apr. 23	Dec. 1
1885	Apr. 27	Dec. 5	1890	Apr. 18	Dec. 2	1895	Apr. 12	Dec. 1
1886	Apr. 22	Nov. 30	1891	May 15	Dec. 10	1896	Apr. 24	.....

Average date of opening, April 25; average date of closing, December 1; average number of days closed, 145.

Authority: Mr. J. T. Kingston, jr., postmaster, 1896.

NOTE.—Compared with Duluth for interpolation for twenty years' period.

No. 5.—BELLE ISLE LIGHT-HOUSE, DETROIT RIVER, MICHIGAN.

[42° 20′ latitude north. 82° 58′ longitude west.]

Year.	Opened.	Closed.	Year.	Opened.	Closed.	Year.	Opened.	Closed.
1882	May 15	Dec. 11	1887	Apr. 3	Dec. 22	1892	Apr. 4	Dec. 25
1883	Apr. 16	Dec. 21	1888	Apr. 4	Dec. 22	1893	Apr. 5	Dec. 17
1884	Mar. 30	Dec. 19	1889	Mar. 25	Dec. 31	1894	Mar. 14	Dec. 29
1885	Apr. 20	Dec. 31	1890	Mar. 22	Dec. 15	1895	Apr. 6	Dec. 20
1886	Mar. 28	Dec. 15	1891	Apr. 22	Dec. 14	1896	Apr. 4	.....

Average date of opening, April 3; average date of closing, December 20; average number of days closed, 104.

Authority: Commander William Folger, U. S. N., Eleventh light-house district.

NOTE.—Compared with Windmill Point light-house for interpolation for twenty years' period.

No. 6.—BELLEVILLE, ONTARIO.

[44° 10′ latitude north. Altitude, 244.53 feet. 77° 23′ longitude west.]

Year.	Opened.	Closed.	Year.	Opened.	Closed.	Year.	Opened.	Closed.
1871	.....	Nov. 28	1880	Mar. 20	Nov. 22	1889	Apr. 13	Nov. 30
1872	Apr. 18	Nov. 28	1881	Apr. 9	Dec. 10	1890	Apr. 12	Nov. 13
1873	Apr. 16	Nov. 20	1882	Mar. 10	Dec. 2	1891	Apr. 17	Nov. 28
1874	Apr. 4	Nov. 29	1883	Apr. 26	Dec. 14	1892	Apr. 13	Nov. 28
1875	Apr. 12	Nov. 28	1884	Apr. 19	Dec. 12	1893	Apr. 23	Nov. 18
1876	Apr. 18	Dec. 1	1885	Apr. 19	Dec. 5	1894	Apr. 2	Nov. 28
1877	Apr. 6	Dec. 31	1886	Apr. 19	Nov. 30	1895	Apr. 23	Dec. 1
1878	Mar. 11	Dec. 7	1887	Apr. 25	Nov. 30	1896	Apr. 20	.....
1879	Apr. 17	Dec. 14	1888	Apr. 23	Nov. 25			

Average date of opening, April 12; average date of closing, December 2; average number of days closed, 131.

Authorities: General Report Public Works, Canada, 1867–1882. Annual Reports of the Department of Railways and Canals, Dominion of Canada, 1883–1889. Department of Public Works, Dominion of Canada, 1896.

No. 7.—BISMARCK, N. DAK.

[46° 47′ latitude north. Altitude, 1,618 feet. 100° 38′ longitude west.]

Year.	Opened.	Closed.	Year.	Opened.	Closed.	Year.	Opened.	Closed.
1871	Apr. 3	.....	1880	Mar. 30	Nov. 18	1889	Mar. 21	Nov. 13
1872	Apr. 15	Dec. 11	1881	Mar. 29	Nov. 17	1890	Apr. 4	Dec. 3
1873	Mar. 17	Dec. 5	1882	Apr. 5	Nov. 11	1891	Apr. 3	Nov. 5
1874	Apr. 13	Nov. 17	1883	Apr. 10	Nov. 15	1892	Apr. 4	Nov. 21
1875	Mar. 25	Nov. 19	1884	Mar. 29	Dec. 14	1893	Apr. 3	Nov. 23
1876	Mar. 25	Nov. 15	1885	Apr. 4	Dec. 6	1894	Mar. 26	Dec. 23
1877	Mar. 30	Nov. 29	1886	Apr. 8	Nov. 17	1895	Mar. 28	Dec. 1
1878	Mar. 16	Dec. 10	1887	Mar. 26	Nov. 23	1896	Mar. 29	
1879	Mar. 29	Nov. 27	1888	Apr. 9	Nov. 14			

Average date of opening, March 31; average date of closing, November 25; average number of days closed, 126.

Authorities: United States Weather Bureau, 1896; Missouri River Commission ("Stages of the Missouri River," 1894).

No. 8.—BRAINERD, MINN.

[46° 29′ latitude north. Altitude, 1,150 feet. 94° 10′ longitude west.]

Year.	Opened.	Closed.	Year.	Opened.	Closed.	Year.	Opened.	Closed.
1876	.....	Nov. 17	1883	Apr. 20	Nov. 15	1890	Apr. 15	Nov. 20
1877	Apr. 18	Nov. 18	1884	Apr. 17	Nov. 16	1891	Apr. 16	Nov. 21
1878	Apr. 20	Nov. 16	1885	Apr. 16	Nov. 20	1892	Apr. 17	Nov. 22
1879	Apr. 19	Nov. 15	1886	Apr. 19	Nov. 22	1893	Apr. 16	Nov. 23
1880	Apr. 18	Nov. 15	1887	Apr. 18	Nov. 21	1894	Apr. 15	Nov. 24
1881	Apr. 15	Nov. 17	1888	Apr. 20	Nov. 19	1895	Apr. 15	Nov. 25
1882	Apr. 16	Nov. 18	1889	Apr. 17	Nov. 20	1896	Apr. 14	.....

Average date of opening, April 17; average date of closing, November 20; average number of days closed, 149.

Authority: Mr. R. K. Whiteley, C. E.

No. 9.—BREWERTON, N. Y.—ONEIDA LAKE.

[43° 14′ latitude north. Altitude, 369 feet. 76° 11′ longitude west.]

Year.	Opened.	Closed.	Year.	Opened.	Closed.	Year.	Opened.	Closed.
1874	.....	Nov. 30	1882	Mar. 19	Dec. 2		.....	Jan. 11
1875	Apr. 16	Nov. 25	1883	Apr. 20	Dec. 17		Jan. 13	Jan. 17
1876	Apr. 21	Nov. 30	1884	Apr. 3	Dec. 17	1890	Jan. 21	Jan. 23
1877	Apr. 20	Dec. 31	1885	Apr. 25	Dec. 7		Feb. 5	Feb. 7
1878	Mar. 14	Dec. 15	1886	Apr. 1	Dec. 2		Mar. 26	Dec. 4
1879	Apr. 24	Dec. 17	1887	Apr. 24	Dec. 23	1891	Apr. 5	Dec. 17
1880	Mar. 8	Mar. 10	1888	Apr. 18	Dec. 17	1892	Apr. 6	Dec. 17
	Apr. 4	Nov. 21		Apr. 12	Dec. 4	1893	Apr. 13	Dec. 3
1881	Apr. 22	.....	1889	Dec. 8	Dec. 30	1894	Mar. 19	Dec. 25
1882	.....	Jan. 1		Dec. 31	.....	1895	Apr. 18	Dec. 28
						1896	Apr. 19	.....

Average date of opening, April 9; average date of closing, December 13; average number of days closed, 117.

Authorities: Mr. E. N. Emmons, Syracuse, N. Y.; Mr. Wm. Pierson Judson, C. E., Oswego, N. Y.

No. 10.—BUFFALO, N. Y.—LAKE ERIE.

[42° 53′ latitude north. Altitude, 571 feet. 78° 53′ longitude west.]

Year.	Opened.	Closed.	Year.	Opened.	Closed.	Year.	Opened.	Closed.
1807	June 1*a*		1837	May 5		1867	Apr. 21	
1808			1838	Mar. 31		1868	Apr. 19	
1809	May 26		1839	Apr. 11		1869	May 2	
1810	Apr. 30		1840	Apr. 24		1870	Apr. 16	
1811	June 4 *a*		1841	Apr. 14		1871	Apr. 1	Dec. 27
1812			1842	Mar. 7		1872	May 5*a*	Dec. 18
1813			1843	May 6		1873	Apr. 29	Nov. 28
1814	Apr. 19		1844	Mar. 8		1874	Apr. 18	Dec. 5
1815			1845	Apr. 3		1875	May 12*a*	Dec. 11
1816	May 16		1846	Apr. 4		1876	May 10*a*	Dec. 17
1817	Apr. 29		1847	Apr. 23		1877	Apr. 20	Dec. 13
1818	Apr. 21		1848	Apr. 9		1878	Mar. 16	Dec. 7
1819	May 6		1849	Mar. 25		1879	Apr. 24	Dec. 14
1820	May 1		1850	Mar. 25		1880	Mar. 19	Dec. 8
1821	May 13		1851	Apr. 2		1881	May 1*a*	Dec. 30
1822	Apr. 15		1852	Apr. 20		1882	Mar. 26	Dec. 1
1823	May 3		1853	Apr. 14		1883	Apr. 25	Dec. 7
1824	Apr. 28		1854	Apr. 29		1884	Apr. 22	Dec. 6
1825	Mar. 12		1855	Apr. 21		1885	May 2*a*	Nov. 9
1826	May 23		1856	May 2		1886	Apr. 15	Dec. 7
1827	Apr. 21		1857	Apr. 27		1887	Apr. 17	Dec. 14
1828	Apr. 1		1858	Apr. 15		1888	Apr. 28	Dec. 6
1829	May 8		1859	Apr. 7		1889	Apr. 12	Dec. 14
1830	Apr. 11		1860	Apr. 17		1890	Mar. 31	Dec. 28
1831	May 8		1861	Apr. 13		1891	Mar. 7	Dec. 14
1832	Apr. 28		1862	Apr. 15		1892	Mar. 15	Dec. 24
1833	Apr. 24		1863	Apr. 3		1893	Apr. 15	Dec. 16
1834	Apr. 6		1864	Apr. 13		1894	Apr. 1	Dec. 25
1835	May 8		1865	Apr. 26		1895	Apr. 16	Dec. 21
1836	Apr. 27		1866	Apr. 28		1896	Apr. 19	

a First vessel arrives.

Average date of opening, April 9; average date of closing, December 12; average number of days closed, 118.

Authorities: Fifth Annual Report of the State Weather Bureau (N. Y.), 1894; Monthly Weather Review, 1875–1896; Mr. William Thurstone.

No. 11.—CAIRO, ILL.—MISSISSIPPI RIVER.

[37° 00′ latitude north. Altitude, 279 feet. 89° 10′ longitude west.]

Year.	Opened.	Closed.	Year.	Opened.	Closed.	Year.	Opened.	Closed.
1874		Dec. 1	1882	Open.	Dec. 9	1890	Open.	Open.
1875	Feb. 24	Open.	1883	Feb. 13	Dec. 20	1891	Open.	Open.
1876	Open.	Dec. 31	1884	Feb. 4	Dec. 18	1892	Open.	Open.
1877	Feb. 4	Open.	1885	Feb. 4	Dec. 7	1893	Open.	Open.
1878	Open.	Dec. 23	1886	Feb. 17	Dec. 1	1894	Open.	Dec. 29
1879	Jan. 30	Dec. 18	1887	Feb. 8	Dec. 29	1895	Feb. 23	Open.
1880	Jan. 3	Dec. 27	1888	Jan. 2	Open.	1896	Open.	
1881	Feb. 25	Open.	1889	Open.	Open.			

Average date of opening, February 5; average date of closing, January 9; average number of days closed, 27.

Authorities: United States Weather Bureau, 1896; Col. William Halliday.

No. 12.—CAIRO, ILL.—OHIO RIVER.

[37° 00′ latitude north. Altitude, 279 feet. 89° 10′ longitude west.]

Year.	Opened.	Closed.	Year.	Opened.	Closed.	Year.	Opened.	Closed.
1874			1882	Open	Open	1890	Open	Open.
1875	Feb. 22	Feb. 15	1883	Open	Open	1891	Open	Open.
1876	Open	Dec. 31	1884	Open	Open	1892	Open	Open.
1877	Jan. 20	Open	1885	Open	Dec. 9	1893	Open	Open.
1878	Open	Dec. 25	1886	Jan. 19	Open	1894	Open	Dec. 30.
1879	Jan. 26	Open	1887	Open	Open	1895	Feb. 22	Open.
1880	Open	Dec. 29	1888	Open	Open	1896	Open	
1881	Jan. 19	Open	1889	Open	Open			

Average date of opening, February 3; average date of closing, January 26; average number of days closed, 8.

Authorities: United States Weather Bureau, 1896; Col. William Halliday.

No. 13.—CAMPBELLTON, NEW BRUNSWICK.

[48° 01′ latitude north. 66° 40′ longitude west.]

Year.	Opened.	Closed.	Year.	Opened.	Closed.	Year.	Opened.	Closed.
1871	May 4	.....	1880	May 6	Nov. 23	1889	Apr. 25	Nov. 26
1872	Apr. 29	.....	1881	May 4	Dec. 10	1890	May 6	Dec. 1
1873	Apr. 30	Dec. 1	1882	May 11	Dec. 1	1890	.....	Jan. 12
1874	Apr. 10	Dec. 3	1883	May 9	Dec. 4	1891	Apr. 23	.....
1875	May 8	Nov. 25	1884	Apr. 27	Dec. 12	1892	Apr. 27	Dec. 24
1876	May 11	Dec. 10	1885	May 6	Dec. 10	1893	Apr. 8	Dec. 2
1877	Apr. 24	Dec. 10	1886	May 26	Dec. 4	1894	Apr. 27	Nov. 19
1878	Apr. 21	Dec. 21	1887	May 6	Dec. 1	1895	Apr. 27	Nov. 23
1879	Apr. 29	Dec. 19	1888	May 8	Nov. 18	1896	May 1	.....

Average date of opening, May 1; average date of closing, December 6; average number of days closed, 146.

Authority: Department of Public Works, Dominion of Canada, 1896.

No. 14.—CAPE VINCENT, N .Y.

[43° 51′ latitude north. Altitude, 244.53 feet. 76° 19′ longitude west.]

Year.	Opened.	Closed.	Year.	Opened.	Closed.	Year.	Opened.	Closed.
1876	Apr. 23	Jan. 1	1882	Mar. 19	.....	1889	Mar. 28	Dec. 27
1876	.....	Dec. 21	1883	.....	Jan. 1	1890	Mar. 31	Dec. 21
1877	Apr. 6	.....	1883	Apr. 20	Dec. 25	1891	Apr. 4	Dec. 20
1878	Mar. 9	Jan. 1	1884	Apr. 12	Dec. 25	1892	Apr. 4	Dec. 20
1879	Apr. 19	Jan. 1	1885	May 1	Dec. 28	1893	Apr. 12	Dec. 16
1880	Apr. 1	Jan. 1	1886	Apr. 12	Dec. 28	1894	Apr. 7	Dec. 17
		Dec. 29	1887	Apr. 17	Dec. 26	1895	Apr. 20	Dec. 19
1881	Apr. 13	.....	1888	Apr. 24	Dec. 27	1896	Apr. 21	.....
1882	.....	Jan. 6						

Average date of opening, April 10; average date of closing, December 20; average number of days closed, 111.

Authority: Rev. S. W. Strowger, rector St. John's Church, Cape Vincent.

No. 15.—CAZENOVIA, N. Y.—LAKE OWAHGENA.

[42° 56′ latitude north. Altitude, 1,177 feet. 75° 54′ longitude west.]

Year.	Opened.	Closed.	Year.	Opened.	Closed.	Year.	Opened.	Closed.
1835	Apr. 12	.....	1857	*a* Apr. 9	Dec. 13	1880	Apr. 4	Nov. 24
1836	Apr. 21	Dec. 7	1858	Apr. 3	Dec. 11	1881	Apr. 24	Dec. 11
1837	.....	Dec. 15	1859	Mar. 20	Dec. 11	1882	Mar. 3	Dec. 5
1838	Apr. 12	Nov. 30	1860	Mar. 27	Dec. 10	1883	Apr. 18	Dec. 15
1839	Apr. 11	Dec. 5	1861	Apr. 10	Dec. 25	1884	Apr. 3	Dec. 17
1840	Apr. 8	.....	1862	Apr. 22	Dec. 7	1885	Apr. 25	Dec. 16
1841	Apr. 25	.....	1863	Apr. 23	Dec. 11	1886	Mar. 31	Dec. 4
1842	Mar. 21	.....	1864	Apr. 17	Dec. 13	1887	Apr. 23	Dec. 23
1843	Apr. 26	.....	1865	Mar. 29	Dec. 16	1888	Apr. 14	Dec. 14
1844	Apr. 12	Nov. 30	1866	Apr. 11	Dec. 15	1889	Apr. 16	.....
1845	Mar. 31	Dec. 7	1867	Apr. 15	Dec. 10	1890	.....	Jan. 17
1846	Apr. 8	Dec. 16	1868	Apr. 3	Dec. 10		.....	Dec. 7
1847	Apr. 26	Dec. 21	1869	Apr. 20	*b* Nov. 26	1891	Apr. 10	Dec. 19
1848	Jan. 1	Jan. 7	1870	Apr. 16	Dec. 17		Dec. 22	Dec. 31
	Apr. 4	Dec. 27	1871	Mar. 11	Dec. 1	1892	Apr. 5	Dec. 18
1849	Apr. 5	Dec. 24	1872	Apr. 24	Dec. 5	1893	Apr. 12	Dec. 5
1850	Apr. 22	Dec. 14	1873	Apr. 30	Nov. 27	1894	Mar. 18	Dec. 23
1851	Mar. 30	Dec. 12	1874	Apr. 21	Dec. 5	1895	Apr. 21	Dec. 9
1852	Apr. 20	Dec. 22	1875	Apr. 14	Nov. 30	1895	Dec. 21	.....
1853	Apr. 17	Dec. 20	1876	Apr. 18	Dec. 4	1896	.....	Jan. 5
1854	Apr. 8	Dec. 8	1877	Apr. 24	Dec. 29	1896	Apr. 16	.....
1855	Apr. 24	Dec. 12	1878	Mar. 16	Dec. 17			
1856	Apr. 26	Dec. 8	1879	Apr. 27	Dec. 18			

a "Lake open almost entirely in February."

b "In winter of 1869–70 there was a large open space near Beckwiths Bay and Evergreen Point until February, and the cause is a mystery, as the ice at the south and north ends of the lake was firm enough to be driven upon."

Average date of opening, April 12; average date of closing, December 13; average number of days closed, 120.

Authorities: Mr. L. W. Ledyard, Mr. W. S. Smyth, Mr. Charles Stebbins.

No. 16.—CHARITY ISLAND LIGHT-HOUSE, SAGINAW BAY, MICHIGAN.

[44° 02′ latitude north. 83° 26′ longitude west.]

Year.	Opened.	Closed.	Year.	Opened.	Closed.	Year.	Opened.	Closed.
1874	Mar. 20	Nov. 29	1882	Mar. 6	Dec. 16	1890	Mar. 16	Dec. 24
1875	Apr. 21	Dec. 19	1883	Apr. 16	Dec. 18	1891	Apr. 9	Dec. 23
1876	Apr. 15	Nov. 29	1884	Apr. 10	Dec. 16	1892	Apr. 6	Dec. 23
1877	Apr. 23	Dec. 28	1885	Apr. 24	Dec. 15	1893	Apr. 8	Dec. 28
1878	Mar. 14	Dec. 7	1886	Apr. 17	Dec. 14	1894	Mar. 17	Dec. 23
1879	Apr. 7	Dec. 19	1887	Apr. 17	Dec. 21	1895	Apr. 9	Dec. 31
1880	Mar. 25	Dec. 9	1888	Apr. 8	Dec. 18	1896	Apr. 3	.....
1881	Apr. 26	Dec. 31	1889	Mar. 24	Dec. 31			

Average date of opening, April 6; average date of closing, December 17; average number of days closed, 110.

Authority: Commander William Folger, U. S. N., Eleventh light-house district.

No. 17.—CHARLESTON, W. VA.—GREAT KANAWHA RIVER.

[38° 21′ latitude north. Altitude, 619 feet. 81° 35′ longitude west.]

Year.	Opened.	Closed.	Year.	Opened.	Closed.	Year.	Opened.	Closed.
1873	Open.	Open.	1883	Open.	Open.	1890	Open.	Open.
1874	Open.	Open.	1884	Open.	Open.	1891	Open.	Open.
1875	Jan. 25	Jan. 19	1885	Jan. 30	Jan. 29	1892	Dec. 31	Dec. 26
	Feb. 20	Feb. 10		Feb. 28	Feb. 17	1893	Jan. 30	Jan. 1
1876	Dec. 31	Dec. 9	1886	Jan. 25	Jan. 11	1894	Open.	Open.
1877	Jan. 13	Jan. 1		Feb. 10	Feb. 4	1895	Jan. 5	Jan. 1
1878	Dec. 31	Dec. 25		Dec. 13	Dec. 7	1896	Jan. 12	Jan. 6
1879	Jan. 17	Jan. 1	1887	Dec. 31	Dec. 30		Feb. 25	Feb. 20
1880	Dec. 31	Dec. 29	1888	Jan. 5	Jan. 1			
1881	Jan. 7	Jan. 1		Jan. 30	Jan. 28			
1882	Open.	Open.	1889	Open.	Open.			

Average date of opening, January 28; average date of closing, January 20; average number of days closed, 8.

Authority: Mr. Addison M. Scott, resident United States engineer.

No. 18.—CHARLOTTETOWN, PRINCE EDWARD ISLAND.

[46° 14′ latitude north. 63° 07′ longitude west.]

Year.	Opened.	Closed.	Year.	Opened.	Closed.	Year.	Opened.	Closed.
1867	Apr. 16	Dec. 7	1878	Apr. 8	Dec. 30	1889	Mar. 30	Dec. 31
1868	Apr. 24	Dec. 10	1879	Apr. 24	Dec. 19	1890	Apr. 10	Dec. 13
1869	Apr. 15	.....	1880	Apr. 28	Dec. 1	1891	Apr. 15	.....
1870	.....	Jan. 10	1881	Apr. 19	Dec. 27	1892	.....	Jan. 25
1870	Apr. 5	Dec. 23	1882	May 6	Dec. 29	1892	Mar. 20	Dec. 24
1871	Mar. 20	Nov. 30	1883	Apr. 18	Dec. 23	1893	Apr. 8	Dec. 19
1872	Apr. 20	Dec. 20	1884	Apr. 24	Dec. 20	1894	Apr. 11	Dec. 24
1873	Apr. 22	Dec. 11	1885	Apr. 22	.....	1895	Apr. 24	.....
1874	Apr. 18	Dec. 19	1886	.....	Jan. 9	1896	.....	Jan. 27
1875	Apr. 5	Nov. 29	1886	Apr. 20	Dec. 29	1896	Apr. 12	
1876	Apr. 23	Dec. 15	1887	Apr. 26	Dec. 27			
1877	Apr. 12	.....	1888	Apr. 21	.....			
1878	.....	Jan. 4	1889	.....	Jan. 12			

Average date of opening, April 15; average date of closing, December 23; average number of days closed, 113.

Authorities: General report public works, Canada, 1867-1882; Annual Reports of Railways and Canals Department, Dominion of Canada, 1883-1889; Department of Public Works, Dominion of Canada, 1896.

No. 19.—CHEBOYGAN LIGHT-HOUSE, MICHIGAN.

[45° 40′ latitude north. Altitude, 579.60 feet. 84° 25′ longitude west.]

Year.	Opened.	Closed.	Year.	Opened.	Closed.	Year.	Opened.	Closed.
1880	.....	Dec. 8	1886	Apr. 15	Dec. 13	1892	Apr. 3	Dec. 31
1881	Apr. 29	Dec. 31	1887	Apr. 22	Dec. 19	1893	Apr. 13	Dec. 17
1882	Mar. 26	Dec. 12	1888	Apr. 29	Dec. 18	1894	Mar. 17	Dec. 18
1883	Apr. 11	Dec. 15	1889	Apr. 1	Dec. 31	1895	Apr. 7	Dec. 16
1884	Apr. 15	Dec. 8	1890	Mar. 30	Dec. 15	1896	Apr. 7	.....
1885	Apr. 29	Dec. 9	1891	Apr. 13	Dec. 16			

Average date of opening, April 11; average date of closing, December 17: average number of days closed, 115.

Authority: Commander William Folger, U. S. N., Eleventh light-house district.

NOTE.—Compared with Alpena, Mich., for interpolation for twenty years' period.

No. 20.—CHERRY ISLAND LIGHT-HOUSE, QUEBEC.

Year.	Opened.	Closed.	Year.	Opened.	Closed.	Year.	Opened.	Closed.
1862	.....	Dec. 2	1874	Apr. 28	Nov. 29	1886	May 1	Dec. 2
1863	Apr. 28	Dec. 9	1875	May 3	Nov. 27	1887	May 4	Nov. 30
1864	Apr. 23	Dec. 9	1876	May 1	Dec. 4	1888	May 1	Nov. 25
1865	Apr. 24	Dec. 9	1877	Apr. 30	Dec. 2	1889	Apr. 22	Nov. 30
1866	Apr. 30	Dec. 9	1878	Apr. 17	Dec. 3	1890	Apr. 17	Nov. 30
1867	Apr. 28	Nov. 27	1879	May 1	Nov. 30	1891	Apr. 28	Dec. 1
1868	Apr. 27	Dec. 2	1880	Apr. 22	Nov. 25	1892	Apr. 22	Dec. 3
1869	May 5	Nov. 25	1881	Apr. 26	Nov. 27	1893	May 1	Dec. 4
1870	Apr. 27	Dec. 9	1882	Apr. 24	Nov. 30	1894	Apr. 23	Nov. 30
1871	Apr. 19	Nov. 30	1883	May 1	Nov. 30	1895	Apr. 29	Nov. 30
1872	May 1	Dec. 2	1884	Apr. 26	Nov. 29	1896	May 1	.....
1873	Apr. 28	Nov. 26	1885	May 6	Dec. 1			

Average date of opening, April 27; average date of closing, November 30; average number of days closed, 148.

Authority: Mr. F. Gourdeau, deputy minister marine and fisheries, Dominion of Canada.

No. 21.—CHICAGO, ILL.

[41° 53′ latitude north. Altitude, feet. 87° 37′ longitude west.]

Year.	Opened.	Closed.	Year.	Opened.	Closed.	Year.	Opened.	Closed.
1847	.....	Open.	1865	Mar. 17	.....	1883	Feb. 13	(Dec. 19)
1848	Open.	Nov. 27	1866	.....	.....	1884	Feb. 16	(Dec. 12)
1849	May 12	Dec. 22	1867	.....	Dec. 26	1885	Feb. 17	(Jan. 15 (Dec. 24
1850	.....	.....	1868	Mar. 4	Nov. 20			
1851	.....	.....	1869	(Jan. 10) (Mar. 22)	Feb. 8	1886	Mar. 21	Dec. 1
1852	.....	Open.				1887	Feb. 9	.....
1853	Open.	.....	1870	.....	Dec. 1	1888	.....	Feb. 8
1854	.....	.....	1871	.....	Dec. 18	1888	Feb. 18	Open.
1855	.....	Dec. 6	1872	Mar. 18)	Dec. 9	1889	Open.	Open.
1856	Mar. 20	Dec. 1	1873	(Mar. 9)	Dec. 1	1890	Open.	(Open.)
1857	Feb. 18	.....	1874	Jan. 10	Nov. 20	1891	(Open.)	.....
1858	.....	Feb. 15	1875	Apr. 20	Open.	1892	.....	Jan. 9
1858	Mar. 15	Open.	1876	Open.	Nov. 26	1892	(Jan. 27)	Dec. 26
1859	Open.	Dec. 20	1877	Mar. 20	Open.	1893	(Feb. 28)	.....
1860	Feb. 26	Dec. 3	1878	Open.	Dec. 1	1894	.....	Feb. 12
1861	Mar. 1	.....	1879	(Feb. 1)	Open.	1894	Mar. 3	Dec. 27
1862	.....	Dec. 2	1880	Open.	Nov. 14	1895	Feb. 24	.....
1863	Feb. 1	.....	1881	Apr. 2	Open.	1896	.....	Jan. 4
1864	Feb. 8	.....	1882	Open.	(Nov. 30)	1896	Mar. 1	.....

Average date of opening, February 27; average date of closing, January 7; average number of days closed, 51.

Authorities: Mr. Ossian Guthrie, Mr. John S. Sargent, Messrs. Piper & Co.

NOTE.—Compared with Seneca, Ill., for interpolation for twenty years' period. The above dates are for ice closings on streams in the near vicinity of Chicago.

No. 22.—CINCINNATI, OHIO.

[39° 06′ latitude north. Altitude, 431 feet. 84° 30′ longitude west.]

Year.	Opened.	Closed.	Year.	Opened.	Closed.	Year.	Opened.	Closed.
1857	Open.	Open.	1872	Jan. 12	Jan. 9	1885	Feb. 2	Jan. 27
1858	Open.	Open.		Feb. 20	Jan. 27		Feb. 13	Feb. 11
1859	Open.	.....		.....	Dec. 13		Feb. 26	Feb. 20
1860	.....	Jan. 2	1873	Jan. 4	Open.	1886	Jan. 20	Jan. 13
1860	Jan. 10	Open.	1874	Open.	.....		Feb. 8	Feb. 5
1861	Open.	Open.	1875	.....	Jan. 12	1887	.....	Jan. 4
1862	Open.	Open.	1875	Jan. 30	Open.	1887	.....	Dec. 29
1863	Open.	Open.	1876	Open.	Dec. 9	1888	Jan. 14	Jan. 22
1864	Jan. 25	Jan. 4	1877	Jan. 18	Open.	1888	Jan. 3	.....
	Feb. 23	Feb. 19	1878	Open.	Dec. 25		Jan. 31	Open.
1865	Feb. 6	Jan. 30	1879	Jan. 15	Open.	1889	Open.	Open.
1866	Feb. 20	Feb. 15	1880	Open.	Dec. 28	1890	Open.	Open.
		Dec. 30	1881	Jan. 13	.....	1891	Open.	Open.
1867	Feb. 5	.....	1882	.....	Feb. 3	1892	Open.	Dec. 23
1868	.....	Jan. 19	1882	.....	Feb. 14	1893	Feb. 4	Open.
1868	.....	Jan. 31	1882	Feb. 8	.....	1894	Open.	.....
1868	Jan. 23	.....		Feb. 15	Open.	1895	.....	Feb. 9
	Feb. 15	Open.	1883	Open.	.....	1895	Feb. 23	Open.
1869	Open.	Open.	1884	.....	Jan. 7	1895	Open.	.....
1870	Open.	Dec. 24	1884	Jan. 31	.....			
1871	Jan. 14	Dec. 19		Dec. 29	Dec. 25			
	Dec. 24	Dec. 28						
	Dec. 31	.....						

Average date of opening, January 25; average date of closing, January 15; average number of days closed, 10.

Authorities: Reports of Cincinnati Chamber of Commerce, 1895.

No. 23.—CLEVELAND, OHIO.

[41° 30′ latitude north. Altitude, 571.35 feet. 81° 42′ longitude west.]

Year.	Opened.	Closed.	Year.	Opened.	Closed.	Year.	Opened.	Closed.
1871	Mar. 19	Dec. 21	1880	Mar. 9	Dec. 13	1890	Open.	Dec. 9
1872	Mar. 10	Dec. 22	1881	Mar. 24	Dec. 13	1891	Mar. 12	.....
1873	Mar. 11	Dec. 12	1882	Mar. 14	Dec. 11	1892	.....	Jan. 7
1874	Mar. 18	.....	1883	Mar. 7	Dec. 20	1892	Mar. 28	Dec. 10
1875	.....	Jan. 11	1884	Mar. 27	Dec. 15	1893	Mar. 28	Dec. 14
1875	Apr. 1	Dec. 16	1885	Mar. 17	Dec. 28	1894	Mar. 10	Dec. 31
1876	Apr. 4	Dec. 11	1886	Mar. 25	Dec. 26	1895	Apr. 6	Dec. 27
1877	Apr. 10	Dec. 12	1887	Mar. 28	Dec. 15	1896	Mar. 30	.....
1878	Mar. 20	Dec. 15	1888	Mar. 28	Dec. 8			
1879	Apr. 2	Dec. 24	1889	Apr. 1	Open.			

Average date of opening, March 23; average date of closing, December 23; average number of days closed, 90.

Authority: United States Weather Bureau, 1896.

No. 24.—COLLINGWOOD, ONTARIO.

[44° 31′ latitude north. Altitude, 579.60 feet. 80° 02′ longitude west.]

Year.	Opened.	Closed.	Year.	Opened.	Closed.	Year.	Opened.	Closed.
1867	Apr. 20	Nov. 28	1877	Apr. 20	Dec. 8	1887	Apr. 20	Dec. 2
1868	Apr. 20	Dec. 5	1878	May 18	Nov. 27	1888	Apr. 30	Dec. 1
1869	Apr. 28	Dec. 2	1879	May 2	Dec. 9	1889	Apr. 22	Dec. 3
1870	Apr. 22	Dec. 10	1880	Apr. 14	Dec. 2	1890	Apr. 18	Nov. 29
1871	Apr. 1	Dec. 6	1881	May 9	Nov. 29	1891	Apr. 15	Nov. 30
1872	May 3	Nov. 28	1882	Apr. 18	Nov. 3	1892	Apr. 20	Dec. 1
1873	May 7	Nov. 24	1883	Apr. 17	Dec. 10	1893	Apr. 16	Dec. 14
1874	May 9	Nov. 26	1884	Apr. 23	Dec. 31	1894	Apr. 10	Dec. 3
1875	May 9	Nov. 22	1885	May 7	Nov. 24	1895	Apr. 27	Dec. 5
1876	May 2	Dec. 1	1886	Apr. 24	Dec. 3	1896	Apr. 20	.....

Average date of opening, April 25; average date of closing, December 2; average number of days closed, 144.

Authority: Department of Public Works, Dominion of Canada, 1896.

No. 25.—CONSTANTIA, N. Y.—ONEIDA LAKE.

[43° 17′ latitude north. Altitude, 369 feet. 76° 03′ longitude west.]

Year.	Opened.	Closed.	Year.	Opened.	Closed.	Year.	Opened.	Closed.
1845	.....	Dec. 15	1862	Apr. 3	Dec. 4	1880	Apr. 1	Dec. 16
1846	Apr. 3	Dec. 8	1863	Apr. 9	Dec. 20	1881	Apr. 25	Dec. 3
1847	Apr. 10	Dec. 28	1864	Apr. 2	Dec. 13	1882	Apr. 2	Dec. 15
1848	Apr. 1	Dec. 25	1865	Mar. 26	Dec. 5	1883	Apr. 6	Dec. 24
1849	Apr. 12	Dec. 14	1866	Mar. 30	Dec. 11	1884	Apr. 2	Dec. 6
1850	Apr. 9	Dec. 22	1867	Mar. 24	Dec. 25	1885	Apr. 3	Dec. 7
1851	Apr. 15	.....	1868	Apr. 2	Dec. 10	1886	Apr. 2	Dec. 13
1852	.....	Feb. 10	1869	Apr. 5	Dec. 25	1887	Apr. 1	Dec. 25
1852	Apr. 3	Dec. 13	1870	Apr. 1	Dec. 16	1888	Apr. 5	Dec. 13
1853	Mar. 28	Dec. 24	1871	Apr. 3	Dec. 2	1889	Apr. 3	Dec. 25
1854	Apr. 4	Dec. 3	1872	Apr. 12	Dec. 24	1890	Apr. 6	Dec. 22
1855	Apr. 15	Dec. 17	1873	Apr. 1	Dec. 3	1891	Apr. 25	Dec. 16
1856	Apr. 5	Dec. 25	1874	Apr. 6	Dec. 13	1892	Apr. 4	Dec. 11
1857	Apr. 2	Dec. 16	1875	Apr. 2	Dec. 24	1893	Apr. 2	Dec. 24
1858	Apr. 8	Dec. 3	1876	Mar. 27	Dec. 15	1894	Apr. 6	Dec. 17
1859	Apr. 6	Dec. 17	1877	Apr. 3	Dec. 19	1895	Apr. 19	Dec. 28
1860	Apr. 1	Dec. 20	1878	Apr. 1	Dec. 3	1896	Apr. 19	.....
1861	Apr. 7	Dec. 15	1879	Apr. 7	Dec. 25			

Average date of opening, April, 5; average date of closing, December 16; average number of days closed, 110.

Authority: Mr. Wm. Pierson Judson, C. E., Oswego, N. Y.

No. 26.—COPONANING, ONTARIO, FRENCH RIVER.

[46° 00′ latitude north. Altitude, 579.60 feet. 80° 45′ longitude west.]

Year.	Opened.	Closed.	Year.	Opened.	Closed.	Year.	Opened.	Closed.
1877	May 5	Nov. 29	1884	May 5	Dec. 10	1891	Apr. 18	Nov. 30
1878	Apr. 7	Dec. 1	1885	May 8	Dec. 6	1892	Apr. 16	Dec. 3
1879	Apr. 21	Dec. 1	1886	Apr. 24	Dec. 3	1893	Apr. 24	Dec. 2
1880	Apr. 28	Nov. 27	1887	Apr. 29	Dec. 1	1894	Apr. 18	Dec. 2
1881	May 5	Dec. 1	1888	May 12	Dec. 4	1895	Apr. 24	Dec. 2
1882	Apr. 13	Dec. 2	1889	Apr. 21	Dec. 4	1896	Apr. 22	.....
1883	May 4	Dec. 1	1890	Apr. 18	Dec. 2			

Average date of opening, April 25; average date of closing, December 3; average number of day closed, 143.

Authority: Mr. H. B. Elliott.

No. 27.—DAVENPORT, IOWA.

[41° 30′ latitude north. Altitude, 541 feet. 90° 38′ longitude west.]

Year.	Opened.	Closed.	Year.	Opened.	Closed.	Year.	Opened.	Closed.
1871	Feb. 25	Dec. 5	1880	Mar. 6	Nov. 22	1889	Mar. 14	.....
1872	Mar. 23	Nov. 29	1881	Apr. 16	Dec. 29	1890	.....	Jan. 15
1873	Mar. 15	Dec. 28	1882	Mar. 10	Nov. 22	1890	Mar. 22	.....
1874	Mar. 10	Nov. 30	1883	Mar. 27	Dec. 2	1891	.....	Feb. 4
1875	Apr. 2	Nov. 23	1884	Mar. 24	Nov. 22	1891	Mar. 25	Nov. 29
1876	Mar. 7	Dec. 1	1885	Mar. 31	Dec. 5	1892	Mar. 22	Dec. 23
1877	Mar. 30	Nov. 30	1886	Mar. 22	Nov. 24	1893	Mar. 27	Dec. 2
1878	Mar. 9	Dec. 18	1887	Mar. 14	Dec. 21	1894	Mar. 13	Dec. 29
1879	Mar. 16	Dec. 14	1888	Mar. 23	.....	1895	Mar. 1	Dec. 8
			1889	.....	Jan. 9	1896	Feb. 25	.....

Average date of opening, March 19; average date of closing, December 12; average number of days closed, 97.

Authorities: United States Weather Bureau 1896; Reports of the Chief Signal Officer.

No. 28.—DES MOINES RAPIDS, MISSISSIPPI RIVER, MONTROSE, IOWA.

[40° 61′ latitude north. Altitude, 500 feet. 91° 25′ longitude west.]

Year.	Opened.	Closed.	Year.	Opened.	Closed.	Year.	Opened.	Closed.
1875	Mar. 9	Jan. 7	1883	Mar. 1	Dec. 27	1891	Open.	Open.
1876	Open.	Dec. 15	1884	Mar. 15	Dec. 30	1892	Feb. 2	Dec. 23
1877	Feb. 17	Dec. 10	1885	Mar. 14	Dec. 14	1893	Mar. 10	Dec. 4
1878	.....	Dec. 20	1886	Mar. 15	Dec. 2	1894	Mar. 1	Dec. 29
1879	Mar. 6	Dec. 26	1887	Feb. 11	Dec. 21	1895	Feb. 27	.....
1880	Jan. 5	Dec. 8	1888	Mar. 1	Open.		Dec. 17	Dec. 5
1881	Mar. 21	Open.	1889	Mar. 3	Feb. 24	1896	Jan. 16	Jan. 3
1882	Open.	Dec. 15	1890	Jan. 28	Jan. 21		Feb. 23	Feb. 21

Average date of opening, February 20; average date of closing, January 3; average number of days closed, 48.

Authorities: Report of Secretary of War, Engineers, 1893-94; Mr. Fred. Z. Goelnisch, observer Weather Bureau, Keokuk.

No. 29.—DETOUR LIGHT-HOUSE, MOUTH OF ST. MARYS RIVER, MICHIGAN.

[45° 59′ latitude north. Altitude, 579.60 feet. 83° 54′ longitude west.]

Year.	Opened.	Closed.	Year.	Opened.	Closed.	Year.	Opened.	Closed.
1874	May 12	Dec. 5	1882	Apr. 5	Dec. 6	1890	Mar. 30	Dec. 6
1875	Apr. 29	Dec. 10	1883	Apr. 18	Dec. 10	1891	Apr. 11	Dec. 10
1876	Apr. 20	Dec. 10	1884	Apr. 12	Dec. 10	1892	Apr. 7	Dec. 7
1877	Apr. 20	Dec. 8	1885	Apr. 30	Dec. 7	1893	Apr. 12	Dec. 8
1878	Mar. 23	Dec. 8	1886	Apr. 17	Dec. 19	1894	Apr. 8	Dec. 7
1879	Apr. 14	Dec. 8	1887	Apr. 20	Dec. 7	1895	Apr. 4	Dec. 14
1880	Apr. 6	Dec. 6	1888	Apr. 23	Dec. 7	1896	Apr. 14	.....
1881	Apr. 26	Dec. 8	1889	Mar. 28	Dec. 6			

Average date of opening, April 13; average date of closing, December 9; average number of days closed, 125.

Authority: Commander William Folger, U. S. N., Eleventh light-house district.

No. 30.—DETROIT RIVER, MAMAJUDA ISLAND LIGHT-STATION, MICHIGAN.

[42° 20′ latitude north. Altitude, 573.84 feet. 83° 03′ longitude west.]

Year.	Opened.	Closed.	Year.	Opened.	Closed.	Year.	Opened.	Closed.
1872	Apr. 6	.....	1882	Mar. 13	Dec. 10	1891	Mar. 1	Dec. 30
1873	Apr. 7	.....	1883	Apr. 7	Dec. 16	1892	Mar. 16	Dec. 23
1874	Mar. 24	Dec. 15	1884	Apr. 1	Dec. 17	1893	Mar. 29	Dec. 15
1875	Mar. 29	Dec. 17	1885	Apr. 5	Dec. 16	1894	Mar. 16	Dec. 26
1876	Mar. 5	Dec. 8	1886	Mar. 15	Dec. 10	1895	Mar. 31	Dec. 23
1877	Mar. 10	Dec. 21	1887	Mar. 20	Dec. 17	1896	Mar. 30	.....
1878	Mar. 7	Dec. 24	1888	Mar. 27	Dec. 18			
1879	Mar. 9	Dec. 15	1889	Mar. 22	.....			
1880	Mar. 8	Dec. 6	1890	.....	Jan. 1			
1881	Apr. 18	Dec. 30	1890	Mar. 2	Dec. 11			

Average date of opening, March 20; average date of closing, December 17; average number of days closed, 93.

Authorities: Reports of United States Chief Signal Officer, 1871-1886; Annual Report of the Chief of Engineers, United States Army, 1884; Mr. Jared A. Smith, lieutenant-colonel, United States Army Engineers, Tenth light-house district.

No. 31.—DUBOISTOWN, PA.

[41° 14′ latitude north. 77° 08′ longitude west.]

Year.	Opened.	Closed.	Year.	Opened.	Closed.	Year.	Opened.	Closed.
1880	Open.	Nov. 21	1889	Open.	Open.			
1881	Jan. 12	Open.	1890	Open.	Dec. 3	1894	Feb. 11	Jan. 13
1882	Open.	(Dec. 11)	1891	Jan. 29	Open.		Feb. 20	Feb. 2
1883	(Feb. 8)	(Dec. 27)			Jan. 2		Feb. 28	Feb. 17
1884	Mar. 10	Mar. 1	1892	Jan. 14	Feb. 13			Feb. 23
1885	(Apr. 4)	(Feb. 1)		Mar. 30	Mar. 21	1895	Jan. 9	Jan. 19
1886	(Feb. 16)	Jan. 12			Dec. 22		Mar. 31	Dec. 6
	(Mar. 8)	Dec. 3	1893	Mar. 12	Nov. 27		Dec. 22	Dec. 28
1887	Feb. 8	Nov. 22			Dec. 5	1896	Feb. 17	Jan. 5
1888	Dec. 19	Dec. 15					Mar. 22	Mar. 13

Average date of opening, February 12; average date of closing, December 30; average number of days closed, 44.

Authority: Mr. J. L. Wheeler.

NOTE.—Compared with Harrisburg, Pa., for interpolation for twenty years' period.

No. 32.—DUBUQUE, IOWA.

[42° 30′ latitude north. Altitude, 585 feet. 90° 44′ longitude west.]

Year.	Opened.	Closed.	Year.	Opened.	Closed.	Year.	Opened.	Closed.
1871	Mar. 13	Nov. 14	1880	Mar. 5	Nov. 16	1889	Mar. 15	Nov. 29
1872	Apr. 3	Nov. 18	1881	Apr. 12	Nov. 24	1890	Apr. 1	Dec. 4
1873	Apr. 1	Nov. 19	1882	Mar. 2	Nov. 21	1891	Mar. 3	Nov. 15
1874	Mar. 25	Nov. 21	1883	Mar. 29	Nov. 23	1892	Mar. 5	Dec. 10
1875	Apr. 5	Nov. 19	1884	Apr. 1	Nov. 21	1893	Mar. 25	Nov. 24
1876	Mar. 14	Nov. 26	1885	Apr. 5	Nov. 18	1894	Mar. 5	Dec. 29
1877	Feb. 25	Dec. 23	1886	Mar. 27	Dec. 3	1895	Mar. 11	Nov. 25
1878	Mar. 10	Nov. 12	1887	Mar. 12	Nov. 9	1896	Mar. 22	.....
1879	Mar. 22	Nov. 23	1888	Apr. 3	Dec. 21			

Average date of opening, March 21; average date of closing, November 26; average number of days closed, 115.

Authorities: United States Weather Bureau, 1896; Mr. Harry Clark, Diamond Jo Line steamers.

No. 33.—DULUTH, MINN.

[46° 47′ latitude north. Altitude, 600.69 feet. 92° 06′ longitude west.]

Year.	Opened.	Closed.	Year.	Opened.	Closed.	Year.	Opened.	Closed.
1855	Apr. 15	Dec. 16	1870	Apr. 12	Nov. 21	1884	May 1	Dec. 25
1856	Apr. 16	Nov. 21	1871	Apr. 5	Dec. 6	1885	Apr. 27	Nov. 29
1857	May 27*a*	Nov. 20	1872	Mar. 9	Nov. 24	1886	May 7	Dec. 14
1858	Mar. 20	Nov. 20	1873	May 10	Dec. 30	1887	May 4	Dec. 28
1859	May 25*a*	Nov. 9	1874	May 2	Dec. 11	1888	May 11	Dec. 31
1860	Apr. 7	Dec. 4	1875	May 12	Dec. 10	1889	Apr. 11	Dec. 4
1861	June 12*a*	Dec. 12	1876	May 2	Dec. 19	1890	Apr. 16	Dec. 8
1862	Apr. 28	Dec. 16	1877	Apr. 25	Dec. 17	1891	Apr. 30	Dec. 7
1863	May 10	Dec. 7	1878	Mar. 23	.....	1892	Apr. 20	Dec. 6
1864	Apr. 23	Dec. 1	1879	.....	Jan. 2	1893	May 1	Dec. 8
1865	Apr. 22	Dec. 5	1879	Apr. 17	Dec. 12	1894	Apr. 18	Dec. 5
1866	May 5	Dec. 10	1880	May 1	Dec. 17	1895	Apr. 27	Dec. 10
1867	Apr. 19	Dec. 1	1881	May 8	Nov. 26	1896	Apr. 7	.....
1868	Apr. 1	Nov. 21	1882	Apr. 15	Dec. 30			
1869	Apr. 25	Nov. 12	1883	Apr. 9	Dec. 24			

a First boat.

Average date of opening, April 24; average date of closing, December 6; average number of days closed, 139.

Authorities: United States Weather Bureau and Marine Review, 1896; postmaster, Duluth, 1896; Mr. Henry Truelsen, mayor, 1896.

No. 34.—EAGLE BLUFF LIGHT-HOUSE, WISCONSIN.

[45° 10′ latitude north. Altitude, 579.60 feet. 87° 14′ longitude west.]

Year.	Opened.	Closed.	Year.	Opened.	Closed.	Year.	Opened.	Closed.
1887	Apr. 25	Dec. 21	1891	Apr. 21	Dec. 19	1895	Apr. 16	Dec. 25
1888	May 1	Dec. 22	1892	Apr. 12	Dec. 13	1896	Apr. 13	.....
1889	Apr. 3	Dec. 24	1893	Apr. 18	Dec. 13			
1890	Apr. 15	Dec. 24	1894	Mar. 30	Dec. 24			

Average date of opening, April 14; average date of closing, December 20; average number of days closed, 115.

Authority: Commander J. H. Dayton, U. S. N., Ninth light-house district.

NOTE.—Compared with Escanaba, Mich., for interpolation for twenty years' period.

No. 35.—ERIE, PA.

[42° 07′ latitude north. Altitude, 571.35 feet. 80° 05′ longitude west.]

Year.	Opened.	Closed.	Year.	Opened.	Closed.	Year.	Opened.	Closed.
1873	Apr. 17	Dec. 15	1882	Apr. 4	Dec. 8	1891	Apr. 11	Dec. 30
1874	Apr. 4	Dec. 15	1883	Apr. 25	Dec. 15	1892	Apr. 3	Dec. 7
1875	Apr. 15	Dec. 15	1884	Apr. 19	Dec. 13	1893	Mar. 25	.....
1876	Apr. 12	Dec. 10	1885	Apr. 30	Dec. 10	1894	.....	Jan. 17
1877	Apr. 22	Dec. 15	1886	Apr. 13	Dec. 7	1894	Mar. 13	Dec. 21
1878	Apr. 1	Dec. 15	1887	Mar. 15	Dec. 23	1895	Apr. 3	Dec. 28
1879	Apr. 1	Dec. 15	1888	Apr. 25	Dec. 5	1896	Apr. 7	.....
1880	Mar. 20	Dec. 15	1889	Apr. 10	Open.			
1881	Apr. 27	Dec. 15	1890	Open.	Dec. 15			

Average date of opening, April 8; average date of closing, December 21; average number of days closed, 108.

Authorities: United States Weather Bureau, 1896; Mr. Robert J. Saltsman.

No. 36.—ESCANABA, MICH.

[45° 48′ latitude north. Altitude, 579.6 feet. 87° 05′ longitude west.]

Year.	Opened.	Closed.	Year.	Opened.	Closed.	Year.	Opened.	Closed.
1871	Apr. 11	Dec. 6	1880	Apr. 13	Nov. 20	1889	Apr. 4	Dec. 31
1872	Apr. 28	Nov. 30	1881	May 4	Dec. 5	1890	Apr. 16	Dec. 27
1873	May 2	Dec. 10	1882	Apr. 1	Dec. 1	1891	Apr. 27	.....
1874	Apr. 30	Nov. 30	1883	Apr. 24	Dec. 8	1892	.....	Jan. 1
1875	May 4	Dec. 1	1884	Apr. 9	Dec. 9	1892	Apr. 15	Dec. 22
1876	Apr. 27	Dec. 9	1885	May 5	Dec. 1	1893	Apr. 27	Dec. 19
1877	Apr. 18	.....	1886	Apr. 23	Dec. 6	1894	Apr. 16	Dec. 27
1878	.....	Jan. 25	1887	Apr. 28	Dec. 15	1895	Apr. 16	Dec. 28
1878	Mar. 5	Dec. 29	1888	May 2	Dec. 28	1896	Apr. 17	.....
1879	Apr. 25	Dec. 12						

Average date of opening, April 20; average date of closing, December 6; average number of days closed, 135.

Authorities: Mr. Edward C. Carter and Monthly Weather Review, 1871-1889.

No. 37.—FORT BENTON, MONT.

[47° 48′ latitude north. Altitude, 2565 feet. 110° 46′ longitude west.]

Year.	Opened.	Closed.	Year.	Opened.	Closed.	Year.	Opened.	Closed.
1876	(Feb. 22)	.....	1883	Mar. 15	Dec. 22	1890	(Mar. 3)	Feb. 1
1877	.....	(Jan. 3)	1884	Feb. 24	.....	1891	Mar. 20	Dec. 26
1877	(Feb. 26)	.....	1885	.....	(Jan. 22)	1892	.....	Feb. 15
1878	.....	(Jan. 17)	1885	Feb. 28	.....	1892	Feb. 7	Nov. 21
1878	(Feb. 12)	.....	1886	.....	(Jan. 24)	1892	Feb. 24	.....
1879	.....	(Jan. 28)	1886	Feb. 11	.....	1893	.....	Jan. 25
1879	(Feb. 25)	.....	1887	.....	(Jan. 5)	1893	Jan. 3	.....
1880	.....	(Jan. 14)	1887	(Feb. 22)	.....	1893	Mar. 10	.....
1880	(Feb. 27)	.....	1888	.....	(Jan. 15)	1894	.....	Jan. 3
1881	.....	(Jan. 6)	1888	(Mar. 8)	.....	1894	Mar. 12	.....
1881	(Feb. 25)	.....	1889	.....	(Jan. 19)	1895	.....	Jan. 4
1882	.....	(Jan. 5)	1889	(Feb. 17)	.....	1895	Feb. 27	.....
1882	Mar. 15	Jan. 2	1890	.....	(Jan. 3)	1896	.....	.....

Average date of opening, February 27; average date of closing, January 3; average number of days closed, 55.

Authority: Missouri River Commission. (Stages of the Missouri River, 1894.)

NOTE.—Compared with Bismarck, N. Dak., for interpolation for twenty years' period.

No. 38.—FORT BUFORD, N. DAK.

[48° 02′ latitude north. Altitude, 1,855 feet. 104° 01′ longitude west.]

Year.	Opened.	Closed.	Year.	Opened.	Closed.	Year.	Opened.	Closed.
1879	Apr. 19	Nov. 8	1885	Apr. 28	Nov. 9	1891	Mar. 19	Nov. 14
1880	Apr. 25	Nov. 12	1886	May 5	Nov. 14	1892	Mar. 29	Nov. 24
1881	Apr. 16	Nov. 9	1887	Apr. 13	Nov. 10	1893	Apr. 2	Nov. 26
1882	Apr. 5	Nov. 6	1888	May 24	Oct. 19	1894	Mar. 31	Nov. 18
1883	Apr. 13	Nov. 8	1889	(Mar. 7)	(Nov. 22)	1895	Mar. 29	Nov. 9
1884	Apr. 20	Nov. 8	1890	(Mar. 26)	Dec. 4	1896	Apr. 1	.....

Average date of opening, April 13; average date of closing, November 13; average number of days closed, 151.

Authorities: United States Weather Bureau, 1896; United States Engineer's Office, Sioux City, Iowa, 1896; Missouri River Commission ("Stages of the Missouri River," 1894); Mr. George Breugger, postmaster, Williston, N. Dak.

NOTE.—Compared with Bismarck, N. Dak., for interpolation for twenty years' period.

No. 39.—FORT CUSTER, MONT.

[45° 46′ latitude north. Altitude, 2,727 feet. 107° 48′ longitude west.]

Year.	Opened.	Closed.	Year.	Opened.	Closed.	Year.	Opened.	Closed.
1876	(Mar. 12)	(Nov. 30)	1884	Mar. 19	Dec. 17	1891	(Mar. 21)	(Nov. 29)
1877	(Mar. 17)	(Dec. 14)	1885	Mar. 12	Dec. 10	1892	(Mar. 22)	(Dec. 6)
1878	(Mar. 3)	(Dec. 25)	1886	Feb. 28	Nov. 20	1893	(Mar. 21)	(Dec. 8)
1879	(Mar. 16)	(Dec. 12)	1887	Mar. 13	Nov. 24	1894	(Mar. 13)	.....
1880	(Mar. 17)	Nov. 17	1888	Mar. 19	Dec. 25	1895	.....	(Jan. 7)
1881	(Mar. 16)	(Dec. 2)	1889	Apr. 25	Nov. 17	1895	(Mar. 15)	(Dec. 16)
1882	Mar. 29	Nov. 12	1890	Mar. 22	.....	1896	(Mar. 16)	.....
1883	Mar. 15	Dec. 8	1891	.....	Feb. 1			

Average date of opening, March 18; average date of closing, December 9; average number of days closed, 99.

Authority: United States Weather Bureau.

NOTE.—Compared with Bismarck, N. Dak., for interpolation for twenty years' period.

No. 40.—FORT GRATIOT RANGE LIGHT-HOUSE, MICH.

[43° 00′ latitude north. Altitude, 579.60 feet. 82° 25′ longitude west.]

Year.	Opened.	Closed.	Year.	Opened.	Closed.	Year.	Opened.	Closed.
1874	Mar. 21	Dec. 12	1882	Mar. 11	Dec. 14	1890	Mar. 13	Dec. 25
1875	Apr. 10	Dec. 15	1883	Apr. 17	Dec. 19	1891	Apr. 19	Dec. 26
1876	Apr. 9	Dec. 11	1884	Apr. 8	Dec. 19	1892	Apr. 6	Dec. 31
1877	Apr. 19	Dec. 22	1885	Apr. 22	Dec. 31	1893	Apr. 9	Dec. 18
1878	Mar. 10	Dec. 19	1886	Apr. 29	Dec. 15	1894	Mar. 23	Dec. 24
1879	Apr. 3	Dec. 19	1887	Apr. 12	Dec. 23	1895	Apr. 7	Dec. 19
1880	Mar. 22	Dec. 11	1888	Apr. 12	Dec. 13	1896	Apr. 8	.....
1881	Apr. 25	Dec. 31	1889	Apr. 12	Dec. 18			

Average date of opening, April 6; average date of closing, December 19, average number of days closed, 108.

Authority: Commander William Folger, U. S. N., Eleventh light-house district.

No. 41.—GEORGETOWN, PRINCE EDWARD ISLAND.

[46° 11′ latitude north. 62° 35′ longitude west.]

Year.	Opened.	Closed.	Year.	Opened.	Closed.	Year.	Opened.	Closed.
1868	.....	.....	1878	Apr. 7	Jan. 29	1888	Apr. 30	Jan. 21
1869	Apr. 15	.....	1879	Apr. 7	Jan. 30	1889	Mar. 6	Feb. 25
1870	Mar. 25	Jan. 25	1880	Apr. 21	Jan. 3	1890	Mar. 15	Feb. 11
1871	.....	.....	1881	Apr. 24	Jan. 3	1891	Mar. 30	Jan. 29
1872	.....	.....	1882	May 7	Feb. 3	1892	Mar. 27	Feb. 11
1873	.....	.....	1883	Apr. 14	Jan. 11	1893	Apr. 10	Jan. 15
1874	Apr. 18	Jan. 31	1884	Apr. 24	Jan. 12	1894	Mar. 22	Jan. 11
1875	May 4	Jan. 5	1885	Apr. 24	Feb. 26	1895	Apr. 23	Jan. 28
1876	Apr. 20	Jan. 10	1886	Mar. 30	Feb. 23	1896	Apr. 2	Jan. 25
1877	Mar. 30	Jan. 13	1887	Apr. 6	Feb. 8			

Average date of opening, April 10; average date of closing, January 26; average number of days closed, 74.

Authorities: General Report Public Works, Canada, 1867-1882; Annual Reports of the Department of Railways and Canals, Dominion of Canada, 1883-1889; Department of Public Works, Dominion of Canada, 1896.

No. 42.—GODERICH, ONTARIO.

[43° 45′ latitude north. Altitude, 579.60 feet. 81° 33′ longitude west.]

Year.	Opened.	Closed.	Year.	Opened.	Closed.	Year.	Opened.	Closed.
1867	Apr. 20	Dec. 2	1877	Apr. 20	Dec. 4	1887	May 2	Nov. 23
1868	May 1	Dec. 6	1878	Apr. 6	Dec. 10	1888	Apr. 28	Nov. 24
1869	Apr. 25	Dec. 3	1879	Apr. 12	Dec. 1	1889	Apr. 8	Nov. 28
1870	Apr. 18	Nov. 28	1880	Mar. 20	Dec. 10	1890	May 5	Dec. 16
1871	May 2	Dec. 5	1881	Mar. 1	Dec. 1	1891	Apr. 4	Dec. 5
1872	Apr. 15	Nov. 25	1882	Apr. 3	Dec. 7	1892	Apr. 4	Dec. 3
1873	Apr. 12	Dec. 4	1883	Apr. 26	Dec. 3	1893	Apr. 22	Nov. 27
1874	Apr. 30	Nov. 30	1884	Apr. 20	Dec. 15	1894	Mar. 15	Dec. 4
1875	May 1	Dec. 10	1885	May 6	Dec. 4	1895	Apr. 20	Nov. 23
1876	May 4	Dec. 1	1886	May 19	Nov. 30	1896	Apr. 13	.....

Average date of opening, April 16; average date of closing, December 4; average number of days closed, 133.

Authorities: General Report Public Works, Canada, 1867–1882; Annual Reports of the Department of Railways and Canals, Dominion of Canada, 1883–1889; Department of Public Works, Dominion of Canada, 1896.

No. 43.—GRAND FORKS, N. DAK.

[47° 55′ latitude north. Altitude, 784 feet. 97° 01′ longitude west.]

Year.	Opened.	Closed.	Year.	Opened.	Closed.	Year.	Opened.	Closed.
1870	.....	.....	1879	.....	.....	1888	Apr. 15	Dec. 14
1871	.....	.....	1880	.....	.....	1889	.....	Nov. 5
1872	.....	.....	1881	.....	.....	1890	Apr. 14	Nov. 12
1873	.....	Oct. 29	1882	.....	Nov. 11	1891	Apr. 16	Nov. 12
1874	.....	.....	1883	.....	Nov. 12	1892	Apr. 17	Nov. 14
1875	.....	.....	1884	.....	Nov. 19	1893	Apr. 18	Nov. 4
1876	.....	.....	1885	.....	Dec. 5	1894	Apr. 15	Nov. 10
1877	.....	.....	1886	.....	Nov. 10	1895	Apr. 6	Nov. 1
1878	.....	.....	1887	.....	.....	1896	Apr. 20	.....

Average date of opening, April 15; average date of closing, November 8; average number of days closed, 158.

Authority: Mr. A. O. Powell, assistant engineer, United States. (1896.) St. Paul, Minn.

No. 44.—GRAND HAVEN, MICH.

[43° 05′ latitude north. Altitude, 579.6 feet. 86° 13′ longitude west.]

Year.	Opened.	Closed.	Year.	Opened.	Closed.	Year.	Opened.	Closed.
1869	.....	Dec. 22	1879	Mar. 7	.....	1887	Open.	Open.
1870	Jan. 15	.....	1880	.....	Jan. 1	1888	Feb. 13	Feb. 4
1871	.....	Jan. 17	1880	Jan. 9	Jan. 10		Feb. 20	Feb. 16
1871	Jan. 22	.....	1881	Jan. 17	Dec. 26	1889	Feb. 26	Feb. 19
1872	.....	Jan. 27	1881	Jan. 12	.....	1890	Open.	Open.
1872	Feb. 2	.....	1882	.....	Jan. 13	1891	Open.	Open.
1873	.....	Jan. 29	1882	Jan. 19	Jan. 24	1892	Open.	Open.
1873	Mar. 25	Open.		Mar. 16		1893	Feb. 14	Feb. 7
1874	Open.	Open.	1883	Open.	Open.		Feb. 21	Feb. 15
1875	Jan. 21	Jan. 4	1884	Feb. 14	Feb. 5		Feb. 27	Feb. 22
	Apr. 4	Jan. 31		Mar. 3	Feb. 19	1894	Feb. 25	Feb. 20
1876	Open.	Open.		Mar. 9	Mar. 8	1895	Open.	Open.
1877	Open.	.....	1885	Mar. 16	Feb. 28	1896	Feb. 20	Feb. 17
1878	.....	Jan. 18	1886	Jan. 30	Jan. 19			
1878	Jan. 28	.....		Feb. 13	Jan. 31			
1879	.....	Mar. 2		Mar. 7	Feb. 14			
				Apr. 2	Mar. 12			

Average date of opening, February 18; average date of closing, February 4; average number of days closed, 14.

Authorities: Mr. A. B. Atwater, superintendent Grand Trunk Railway; Mr. Jacob Boar, Gooderich Transportation Company.

No. 45.—GRAND ISLAND LIGHT-HOUSE, NEAR MUNISING, MICH.

[46° 34′ latitude north. Altitude, 600.69 feet. 86° 41′ longitude west.]

Year.	Opened.	Closed.	Year.	Opened.	Closed.	Year.	Opened.	Closed.
1874	May 9	Dec. 6	1882	Apr. 18	Dec. 1	1890	Apr. 22	Dec. 1
1875	May 21	Dec. 1	1883	May 8	Dec. 2	1891	Apr. 28	Dec. 1
1876	May 15	Dec. 3	1884	May 1	Dec. 1	1892	Apr. 21	Dec. 1
1877	May 1	Nov. 30	1885	May 11	Nov. 30	1893	May 2	Dec. 2
1878	Apr. 3	Nov. 28	1886	May 1	Dec. 4	1894	Apr. 19	Dec. 3
1879	May 6	Dec. 1	1887	May 3	Nov. 30	1895	Apr. 27	Dec. 2
1880	Apr. 27	Nov. 20	1888	May 11	Nov. 30	1896	Apr. 19	.....
1881	May 11	Dec. 5	1889	Apr. 13	Nov. 30			

Average date of opening, April 30; average date of closing, December 1; average number of days closed, 150.

Authority: Commander William Folger, U. S. N., Eleventh light-house district.

No. 46.—GRAND MARAIS LIGHT-HOUSE, MINNESOTA.

[47° 44′ latitude north. Altitude, 600.69′ feet. 90° 20′ longitude west.]

Year.	Opened.	Closed.	Year.	Opened.	Closed.	Year.	Opened.	Closed.
1885	.....	Dec. 21	1889	Mar. 17	Nov. 7	1893	Apr. 30	Dec. 9
1886	Apr. 27	Dec. 22	1890	Apr. 8	Dec. 17	1894	Apr. 15	Dec. 11
1887	May 1	Dec. 28	1891	Apr. 27	Dec. 3	1895	Apr. 9	Dec. 17
1888	May 9	Dec. 28	1892	Apr. 22	Dec. 10	1896	Apr. 12	.....

Average date of opening, April 19; average date of closing, December 13; average number of days closed, 127.

Authority: Commander William Folger, U. S. N., Eleventh light-house district.

NOTE.—Compared with Duluth, Minn., for interpolation for twenty years' period.

No. 47.—GRAND RAPIDS, MICH.

[42° 59′ latitude north. Altitude, 586.60 feet. 85° 50′ longitude west.]

Year.	Opened.	Closed.	Year.	Opened.	Closed.	Year.	Opened.	Closed.
1868	Mar. 16	Dec. 4	1878	Mar. 15	Nov. 26	1888	Apr. 3	Dec. 11
1869	Mar. 26	Dec. 7	1879	Mar. 13	Nov. 15	1889	Mar. 21	Dec. 29
1870	Mar. 24	Nov. 15	1880	Mar. 5	Nov. 19	1890	Mar. 26	Dec. 3
1871	Mar. 20	Nov. 27	1881	Apr. 4	Dec. 18	1891	Apr. 1	Nov. 29
1872	Apr. 2	Nov. 20	1882	Mar. 24	Nov. 30	1892	Mar. 30	Nov. 25
1873	Mar. 30	Nov. 15	1883	Apr. 2	Nov. 14	1893	Feb. 20	.....
1874	Mar. 11	Nov. 25	1884	Mar. 19	Nov. 22	1894	.....	Jan. 2
1875	Mar. 27	Nov. 24	1885	Apr. 9	Dec. 2	1894	Mar. 5	Dec. 31
1876	Mar. 29	Nov. 30	1886	Apr. 1	Nov. 28	1895	Mar. 10	Nov. 28
1877	Mar. 26	Nov. 23	1887	Mar. 23	Nov. 23	1896	Mar. 2	.....

Average date of opening, March 22; average date of closing, November 29; average number of days closed, 113.

Authority: Capt. John Muir, steamer *W. H. Barrett*.

No. 48.—GRAND TRAVERSE LIGHT-HOUSE, MICHIGAN.

[45° 12′ latitude north. Altitude, 579.60 feet. 85° 34′ longitude west.]

Year.	Opened.	Closed.	Year.	Opened.	Closed.	Year.	Opened.	Closed.
1887	Apr. 16	Dec. 18	1891	Apr. 1	Dec. 21	1894	Mar. 19	Dec. 18
1888	Apr. 27	Dec. 16	1892	Apr. 1	Dec. 22	1895	Apr. 11	Dec. 21
1889	Mar. 24	Dec. 16	1893	Apr. 10	Dec. 18	1896	Apr. 1	.....
1890	Mar. 25	Dec. 22						

Average date of opening, April 3; average date of closing, December 21; average number of days closed, 103.

Authority: Commander J. H. Dayton, U. S. N., Ninth light-house district.

NOTE.—Compared with Alpena, Mich., for interpolation for twenty years' period.

No. 49.—GREENBAY, WIS.

[44° 31′ latitude north. Altitude, 579.60 feet. 88° 00′ longitude west.]

Year.	Opened.	Closed.	Year.	Opened.	Closed.	Year.	Opened.	Closed.
1874	Apr. 15	Nov. 28	1881	May 6	Dec. 14	1889	Apr. 8	Dec. 7
1875	Apr. 28	Nov. 28	1882	Apr. 1	Dec. 4	1890	Apr. 11	Dec. 4
1876	Apr. 17	Dec. 1	1883	Apr. 16	Dec. 15	1891	Apr. 23	Nov. 30
1877	Apr. 16	.....	1884	Apr. 24	Dec. 3	1892	Apr. 11	Dec. 1
1878	.....	Jan. 23	1885	Apr. 29	Dec. 6	1893	Apr. 15	Dec. 15
1878	Mar. 13	Dec. 11	1886	Apr. 20	Nov. 26	1894	Mar. 31	Dec. 10
1879	Apr. 15	Nov. 30	1887	Apr. 24	Nov. 7	1895	Apr. 16	Dec. 2
1880	Apr. 1	Nov. 20	1888	May 2	Dec. 12	1896	Apr. 16	.....

Average date of opening, April 15; average date of closing, December 6; average number of days closed, 130.

Authority: Mr. F. W. Conrad, observer Weather Bureau.

No. 50.—GREEN ISLAND LIGHT-HOUSE, WISCONSIN.

[45° 03′ latitude north. Altitude, 579.60 feet. 87° 29′ longitude west.]

Year.	Opened.	Closed.	Year.	Opened.	Closed.	Year.	Opened.	Closed.
1887	Apr. 23	Dec. 24	1891	Apr. 22	Dec. 27	1894	Mar. 22	.....
1888	May 1	Dec. 31	1892	Apr. 6	Dec. 15	1895	.....	Feb. 2
1889	Apr. 4	Dec. 31	1893	Apr. 14	Dec. 13	1894	Apr. 1	Dec. 31
1890	Apr. 5	Dec. 24				1896	Apr. 9	.....

Average date of opening, April 9; average date of closing, December 29; average number of days closed, 101.

Authority: Commander J. H. Dayton, U. S. N., Ninth light-house district.

NOTE.—Compared with Escanaba, Mich., for interpolation for twenty years' period.

No. 51.—GROSSE POINTE LIGHT-HOUSE, LAKE ST. FRANCIS, QUEBEC.

[Altitude, 153.50 feet.]

Year.	Opened.	Closed.	Year.	Opened.	Closed.	Year.	Opened.	Closed.
1872	May 2	Dec. 1	1881	Apr. 28	Nov. 29	1890	May 1	Dec. 2
1873	Apr. 29	Nov. 25	1882	Apr. 28	Dec. 2	1891	Apr. 28	Nov. 30
1874	May 1	Nov. 29	1883	Apr. 29	Dec. 13	1892	May 1	Nov. 30
1875	May 3	Nov. 27	1884	Apr. 30	Dec. 14	1893	Apr. 29	Dec. 2
1876	May 1	Nov. 30	1885	May 6	Dec. 4	1894	Apr. 26	Nov. 30
1877	May 3	Dec. 2	1886	May 1	Dec. 3	1895	Apr. 29	Nov. 30
1878	Apr. 20	Dec. 14	1887	May 1	Dec. 2	1896	.....	.....
1879	May 1	Dec. 3	1888	May 1	Dec. 2			
1880	Apr. 29	Nov. 25	1889	Apr. 22	Dec. 1			

Average date of opening, April 29; average date of closing, December 2; average number of days closed, 148.

Authority: Mr. F. Gourdeau, deputy minister marine and fisheries, Dominion of Canada.

No. 52—HAMILTON ISLAND LIGHT-HOUSE, SUMMERSTOWN, ONTARIO.

[Altitude, 153.50 feet.]

Year.	Opened.	Closed.	Year.	Opened.	Closed.	Year.	Opened.	Closed.
1873	.....	Nov. 25	1881	Apr. 25	Nov. 26	1889	Apr. 22	Dec. 1
1874	Apr. 28	Nov. 28	1882	Apr. 23	Nov. 30	1890	Apr. 21	Nov. 30
1875	May 3	Nov. 25	1883	May 1	Dec. 1	1891	Apr. 28	Dec. 1
1876	May 1	Dec. 2	1884	Apr. 28	Dec. 1	1892	Apr. 27	Dec. 4
1877	Apr. 30	Dec. 2	1885	May 6	Dec. 2	1893	May 1	Dec. 3
1878	Apr. 16	Dec. 2	1886	Apr. 29	Dec. 2	1894	Apr. 23	Dec. 1
1879	May 1	Dec. 3	1887	May 3	Dec. 1	1895	Apr. 28	Dec. 1
1880	Apr. 21	Nov. 25	1888	May 1	Dec. 1	1896	May 1	.....

Average date of opening, April 28; average date of closing, November 30; average number of days closed, 149.

Authority: Mr. F. Gourdeau, deputy minister marine and fisheries, Dominion of Canada.

No. 53.—HARRISBURG, PA.—SUSQUEHANNA RIVER.

[40° 16′ latitude north. Altitude, 289.96 feet. 76° 52′ longitude west.]

Year.	Opened.	Closed.	Year.	Opened.	Closed.	Year.	Opened.	Closed.
1870	.....	Dec. 29	1879	Mar. 8	Open.	1891	Open.	Open.
1871	Jan. 15	Feb. 12	1880	Open.	Dec. 10	1892	Open.	Dec. 25
	Feb. 17	Dec. 18	1881	Feb. 11	Open.	1893	Feb. 10	Open.
1872	Mar. 23	Dec. 22	1882	Open.	Dec. 8	1894	Open.	Dec. 29
1873	Jan. 18	Jan. 29	1883	Feb. 5	Dec. 24	1895	Jan. 10	.....
	Feb. 7	Feb. 24	1884	Feb. 7	Open.	1896	.....	Jan. 9
	Mar. 11		1885	Apr. 1	Jan. 29		Feb. 1	Feb. 22
1874	Open.	Open.	1886	Feb. 13	Jan. 15		Feb. 23	.....
1875	Feb. 27	Jan. 10		Mar. 5	Mar. 3			
1876	Open.	Dec. 10	1887	Jan. 25	Jan. 5			
1877	Feb. 3	Open.	1888	Feb. 22	Jan. 20			
1878	Jan. 12	Jan. 8	1889	Open.	Open.			
		Dec. 26	1890	Open.	Open.			

Average date of opening, February 14; average date of closing, January 18; average number of days closed, 27.

Authorities: Mr. William A. Kelker; Mr. T. T. Wierman, jr., C. E.

No. 54.—HARTFORD, CONN.—CONNECTICUT RIVER.

[41° 45′ latitude north. Altitude, 0.00 feet. 72° 39′ longitude west.]

Year.	Opened.	Closed.	Year.	Opened.	Closed.	Year.	Opened.	Closed.
1834	Feb. 23	.....	1857	Mar. 18	Dec. 12	1879	Mar. 15	Dec. 21
1835	Mar. 14	.....	1858	Mar. 20	Dec. 1	1880	Jan. 23	Nov. 22
1836	Apr. 1	.....	1859	Mar. 12	Dec. 10	1881	Mar. 14	.....
1837	Mar. 22	.....	1860	Mar. 5	Dec. 10	1882	.....	Jan. 4
1838	Mar. 4	.....	1861	Feb. 23	Dec. 21	1882	Mar. 3	Dec. 4
1839	Jan. 26	.....	1862	Mar. 29	Dec. 2	1883	Mar. 19	Dec. 15
1840	Mar. 11	.....	1863	Mar. 22	Dec. 9	1884	Mar. 15	Dec. 18
1841	Feb. 26	.....	1864	Mar. 5	Dec. 12	1885	Mar. 28	Dec. 6
1842	Feb. 3	.....	1865	Mar. 17	Dec. 17	1886	Mar. 16	Dec. 5
1843	Apr. 7	.....	1866	Mar. 14	Dec. 8	1887	Mar. 11	Dec. 26
1844	Mar. 15	.....	1867	Mar. 5	Dec. 11	1888	Mar. 30	Dec. 15
1845	Mar. 2	.....	1868	Mar. 24	Dec. 5	1889	Mar. 3	.....
1846	Mar. 14	.....	1869	Mar. 25	Dec. 19	1890	.....	Jan. 11
1847	Mar. 13	.....	1870	Mar. 2	Nov. 30	1890	Feb. 18	Dec. 10
1848	Mar. 9	.....	1871	Mar. 10	Dec. 1	1891	Mar. 1	.....
1849	Mar. 17	.....	1872	Mar. 31	Nov. 29	1892	.....	Jan. 8
1850	Mar. 6	.....	1873	Mar. 30	Nov. 28	1892	Feb. 24	Dec. 23
1851	Feb. 7	.....	1874	Mar. 16	Dec. 24	1893	Mar. 14	Dec. 13
1852	Mar. 15	.....	1875	Apr. 7	Nov. 30	1894	Mar. 8	Dec. 28
1853	Feb. 25	.....	1876	Mar. 17	Dec. 1	1895	Mar. 14	Dec. 20
1854	Mar. 12	Dec. 4	1877	Mar. 10	.....	1896	Mar. 1	.....
1855	Mar. 8	Dec. 9	1878	.....	Jan. 1			
1856	Apr. 7	Dec. 6	1878	Mar. 1	Dec. 20			

Average date of opening, March 12; average date of closing, December 12; average number of days closed, 90.

Authority: Mr. C. C. Goodrich, general manager Hartford and New York Transportation Company.

No. 55.—HENNEPIN, ILL.

[41° 15′ latitude north. Altitude, 438.61 feet. 89° 22′ longitude west.]

Year.	Opened.	Closed.	Year.	Opened.	Closed.	Year.	Opened.	Closed.
1876	.....	(Nov. 11)	1884	Mar. 15	Nov. 26	1891	Mar. 18	Nov. 18
1877	(Feb. 14)	(Open.)	1885	Mar. 27	Dec. 7	1892	Dec. 18	.....
1878	(Open.)	(Nov. 25)	1886	Mar. 6	Nov. 25		.....	Jan. 3
1879	(Mar. 16)	(Nov. 24)	1887	Feb. 17	Nov. 28	1892	Mar. 2	Nov. 23
1880	(Jan. 14)	Nov. 17	1888	Mar. 16	Dec. 20	1893	Mar. 21	Nov. 24
1881	Mar. 20	Nov. 26	1889	Mar. 5	.....	1894	Mar. 3	Nov. 19
1882	Mar. 17	Dec. 5	1890	.....	Jan. 21	1895	Feb. 28	Dec. 3
1883	Mar. 2	Nov. 16	1890	Mar. 11	Dec. 5	1896	Mar. 20	.....

Average date of opening, March 8; average date of closing, November 28; average number of days closed, 100.

Authority: Mr. W. Durley.

NOTE.—Compared with Seneca, Ill., for interpolation for twenty years' period.

No. 56.—JEFFERSON CITY, MO.

[38° 36′ latitude north. Altitude, 523 feet. 92° 14′ longitude west.]

Year.	Opened.	Closed.	Year.	Opened.	Closed.	Year.	Opened.	Closed.
1878	(Feb. 6)	Dec. 28	1885	(Feb. 9)	.....	1889	Mar. 1	Open.
1879	(Feb. 7)	(Dec. 27)	1886	.....	Jan. 11	1890	Open.	Open.
1880	(Jan. 7)	.....	1886	Feb. 14	Dec. 4	1891	Open.	Open.
1881	.....	Jan. 22	1886	Dec. 11	.....	1892	Jan. 26	{Jan. 9
1881	Feb. 7	.....	1887	.....	Jan. 1			{Dec. 26
1882	.....	(Jan. 10)	1887	.....	Dec. 28	1893	Feb. 20	Open.
1882	(Feb. 25)	.....	1887	Jan. 24	.....	1894	Open.	Dec. 31
1883	.....	Jan. 31	1888	.....	Jan. 16	1895	Feb. 27	Open.
1883	Feb. 17	.....	1888	Jan. 6	.....	1896	Open.	.....
1884	.....	Jan. 5	1888	Feb. 4	.....			
1884	Jan. 30	.....	1889	.....	Feb. 24			
1885	.....	(Jan. 3)						

Average date of opening, February 2; average date of closing, January 11; average number of days closed, 22.

Authorities: Report of United States Engineers, 1888–90; Missouri River Commission ("Stages of the Missouri River"), 1894; Capt. J. E. Sanford, United States Engineers, secretary Missouri River Commission.

NOTE.—Compared with Kansas City, Mo., for interpolation for twenty years' period.

No. 57.—KANSAS CITY, MO.

[39° 05′ latitude north. Altitude, 716 feet. 94° 37′ longitude west.]

Year.	Opened.	Closed.	Year.	Opened.	Closed.	Year.	Opened.	Closed.
1874	.....	Dec. 28	1885	Feb. 6	Dec. 13	1890	{Jan. 27}	Open.
1875	Mar. 11	Open.	1885	Dec. 22	.....		{Mar. 9}	
1876	Open.	Dec. 9	1886	.....	Jan. 7	1891	Open.	Open.
1877	Feb. 6	.....	1886	Feb. 13	Dec. 4	1892	Open.	Dec. 20
1878	.....	Jan. 1	1886	Dec. 13	.....	1893	Feb. 21	Dec. 3
1878	Feb. 3	Dec. 22	1887	.....	Jan. 9	1893	Dec. 15	.....
1879	Feb. 4	Dec. 15	1887	Feb. 8	Dec. 2	1894	.....	Dec. 31
1880	{Jan. 4	Nov. 24	1888	Feb. 17	.....	1895	{Jan. 20	Jan. 26
	{Dec. 8	Dec. 29	1889	.....	Jan. 27		{Feb. 18	.....
1881	Feb. 22	Dec. 29	1889	.....	Feb. 20	1896	Jan. 14	.....
1882	Feb. 20	Dec. 4	1889	Feb. 3	.....			
1882	Dec. 11	.....	1889	Mar. 3	.....			
1883	.....	Jan. 3	1890	.....	Jan. 13			
1883	Feb. 15	Dec. 19	1890	.....	Feb. 20			
1884	Feb. 24	Dec. 22						

Average date of opening, February 12; average date of closing, January 5; average number of days closed, 38.

Authorities: Report of United States Missouri River Commission, 1887–1890; Missouri River Commission ("Stages of the Missouri River"), 1894; local forecast official, United States Weather Bureau, 1896.

No. 58.—KEOKUK, IOWA.

[40° 22′ latitude north. Altitude, 477 feet. 91° 26′ longitude west.]

Year.	Opened.	Closed.	Year.	Opened.	Closed.	Year.	Opened.	Closed.
1871	.....	Dec. 4	1881	Mar. 6	Open.	1890	{Jan. 28	Jan. 21
1872	Mar. 14	Dec. 4	1882	Open.	Dec. 17		{Mar. 12	Mar. 1
1873	Mar. 10	Open.	1883	Mar. 1	Dec. 27	1891	Open.	Open.
1874	Open.	Open.	1884	Mar. 16	Dec. 20	1892	Open.	Dec. 26
1875	Mar. 28	Jan. 5	1885	Mar. 14	Dec. 14	1893	Mar. 9	Dec. 31
1876	Open.	Dec. 11	1886	Mar. 14	Dec. 2	1894	Feb. 27	Dec. 30
1877	Feb. 17	Dec. 10	1887	Feb. 10	Dec. 21	1895	{Feb. 27	.....
1878	Mar. 19	Dec. 20	1888	Mar. 1	Open.		{Dec. 17	Dec. 5
1879	Mar. 6	Dec. 25	1889	Mar. 3	Feb. 24	1896	{Jan. 13	Jan. 3
1880	Jan. 5	Dec. 8					{Feb. 23	Feb. 21

Average date of opening, February 25; average date of closing, January 5; average number of days closed, 51.

Authorities: Reports of the United States Chief Signal Officer, 1872–1888; Mr. J. H. Cole.

No. 59.—KINCARDINE, ONTARIO.

[44° 10′ latitude north. Altitude, 579.60 feet. 81° 37′ longitude west.]

Year.	Opened.	Closed.	Year.	Opened.	Closed.	Year.	Opened.	Closed.
1875	Mar. 27	Nov. 20	1883	Apr. 23	Dec. 28	1891	Apr. 22	Nov. 15
1876	May 5	Oct. 27	1884	May 6	Nov. 24	1892	Apr. 5	Dec. 26
1877	Mar. 2	Nov. 12	1885	May 6	Nov. 30	1893	Apr. 2	Nov. 6
1878	Apr. 26	Nov. 16	1886	Apr. 3	Nov. 28	1894	Apr. 4	Nov. 26
1879	Apr. 13	Nov. 20	1887	Apr. 20	Nov. 15	1895	Apr. 10	Nov. 26
1880	May 7	Nov. 5	1888	May 2	Dec. 4	1896	Apr. 9	.....
1881	Apr. 28	Nov. 23	1889	Mar. 26	Nov. 6			
1882	Mar. 27	Nov. 30	1890	Apr. 18	Nov. 16			

Average date of opening, April 15; average date of closing, November 21; average number of days closed, 145.

Authority: Department of Public Works, Dominion of Canada, 1896.

No. 60.—KINGSTON, ONTARIO.

[44° 15′ latitude north. Altitude, 244.53 feet. 76° 29′ longitude west.]

Year.	Opened.	Closed.	Year.	Opened.	Closed.	Year.	Opened.	Closed.
1831	.....	Dec. 19	1855	Apr. 17	.....	1875	Apr. 19	Dec. 23
1832	Apr. 27	Dec. 4	1856	.....	Jan. 1	1876	Apr. 18	Dec. 20
1833	Apr. 7	.....	1856	Apr. 8	Dec. 31	1877	Apr. 9	.....
1834	.....	Jan. 1	1857	Apr. 2	.....	1878	.....	Jan. 8
1834	Mar. 19	Dec. 22	1858	.....	Feb. 2	1878	Mar. 11	.....
1835	Apr. 6	Dec. 31	1858	Apr. 26	.....	1879	.....	Jan. 2
1836	Apr. 23	Dec. 26	1859	.....	Jan. 8	1879	Apr. 21	Dec. 28
1837	Apr. 11	.....	1859	Apr. 15	Dec. 25	1880	Mar. 23	Dec. 21
1838	.....	Jan. 16	1860	Apr. 12	.....	1881	Apr. 12	.....
1838	Apr. 6	Dec. 18	1861	.....	Jan. 10	1882	.....	Jan. 12
1839	Apr. 8	Dec. 26	1861	Apr. 8	.....	1882	Mar. 7	.....
1840	Mar. 19	Dec. 23	1862	.....	Jan. 4	1883	.....	Jan. 4
1841	Apr. 23	Dec. 31	1862	Apr. 14	.....	1883	Apr. 19	Dec. 31
1842	Mar. 24	Dec. 31	1863	.....	Jan. 17	1884	Apr. 19	Dec. 31
1843	Apr. 25	.....	1863	Apr. 16	.....	1885	Apr. 28	.....
1844	.....	Jan. 3	1864	.....	Jan. 1	1886	.....	Jan. 8
1844	Mar. 9	.....	1864	Apr. 5	.....	1886	Apr. 9	Dec. 30
1845	.....	Jan. 12	1865	.....	Jan. 4	1887	Apr. 19	Dec. 30
1845	Apr. 2	.....	1865	Mar. 28	.....	1888	Apr. 12	.....
1846	.....	Jan. 9	1866	.....	Jan. 5	1889	.....	Jan. 19
1846	Mar. 31	.....	1866	Apr. 11	.....	1889	Apr. 2	.....
1847	Apr. 11	.....	1867	.....	Jan. 5	1890	.....	Jan. 23
1848	.....	Jan. 6	1867	Apr. 8	Dec. 18	1890	Mar. 31	Dec. 26
1848	Apr. 3	Dec. 30	1868	Mar. 31	Dec. 24	1891	Apr. 3	.....
1849	Apr. 3	Dec. 31	1869	Apr. 17	.....	1892	.....	Jan. 16
1850	Apr. 5	Dec. 26	1870	.....	Jan. 8	1892	Apr. 6	Dec. 26
1851	Apr. 2	Dec. 22	1870	Apr. 13	Dec. 31	1893	Apr. 12	Dec. 30
1852	Apr. 19	.....	1871	Mar. 16	Dec. 25	1894	Mar. 19	Open.
1853	.....	Jan. 14	1872	Apr. 22	Dec. 21	1895	Apr. 15	Jan. 10
1853	Apr. 4	.....	1873	Apr. 24	.....	1896	Apr. 14	Jan. 2
1854	.....	Jan. 5	1874	.....	Jan. 14			
1854	Apr. 10	.....	1874	Mar. 28	.....			
1855	.....	Jan. 13	1875	.....	Jan. 5			

Average date of opening, April 8; average date of closing, January 2; average number of days closed, 96.

Authorities: General Report Public Works, Canada, 1867–1882; Annual Report of the Department of Railways and Canals, Dominion of Canada, 1883–1889; Department of Public Works, Dominion of Canada, 1896.

No. 61.—LACROSSE, WIS.

[43° 49′ latitude north. Altitude, 628 feet. 91° 15′ longitude west.]

Year.	Opened.	Closed.	Year.	Opened.	Closed.	Year.	Opened.	Closed.
1871	Mar. 13	Nov. 22	1880	Mar. 7	Nov. 19	1889	Mar. 30	Nov. 29
1872	Apr. 8	Nov. 22	1881	Apr. 9	Dec. 31	1890	Mar. 20	Dec. 3
1873	Mar. 19	Nov. 27	1882	Mar. 4	Dec. 8	1891	Mar. 21	Dec. 26
1874	Mar. 28	Nov. 29	1883	Apr. 6	Dec. 18	1892	Mar. 25	Dec. 10
1875	Apr. 7	Nov. 22	1884	Mar. 29	Nov. 24	1893	Apr. 3	Nov. 28
1876	Apr. 7	Nov. 30	1885	Apr. 1	Dec. 7	1894	Mar. 10	Dec. 27
1877	Mar. 27	Dec. 2	1886	Mar. 28	Nov. 29	1895	Mar. 24	Dec. 2
1878	Feb. 22	Dec. 11	1887	Apr. 5	Nov. 28	1896	Mar. 21	.....
1879	Mar. 26	Dec. 12	1888	Apr. 9	Dec. 21			

Average date of opening, March 26; Average date of closing, December 5; average number of days closed, 111.

Authorities: United States Weather Bureau, 1896; Mr. W. U. Simons, observer, Weather Bureau, La Crosse, Wis., 1896.

No. 62.—LAKE CHAMPLAIN, OPPOSITE BURLINGTON.

[44° 30′ latitude north. Altitude, 95.03 feet. 73° 14′ longitude west.]

Year.	Opened.	Closed.	Year.	Opened.	Closed.	Year.	Opened.	Closed.
1816	Apr. 5	Feb. 9	1845	Mar. 26	Feb. 8	1875	Apr. 30	Jan. 16
1817	Apr. 16	Jan. 29	1846	Mar. 30	Feb. 10	1876	Apr. 24	Feb. 2
1818	Apr. 15	Feb. 2	1847	Apr. 24	Feb. 15	1877	Apr. 5	Jan. 15
1819	Apr. 17	Mar. 4	1848	Mar. 31	Feb. 13	1878	Mar. 1	Jan. 29
1820	Mar. 12	Feb. 3 Mar. 8	1849	Mar. 30	Feb. 7	1879	Apr. 22	Jan. 29
			1850	Open.	Open.	1880	Mar. 24	Feb. 2
1821	Apr. 21	Jan. 15	1851	Mar. 30	Feb. 1	1881	Apr. 21	Jan. 16
1822	Mar. 30	Jan. 24	1852	Apr. 21	Jan. 18	1882	Feb. 5 Mar. 4	Feb. 4 Feb. 25
1823	Apr. 5	Feb. 7	1853	Apr. 10	Jan. 28			
1824	Feb. 11	Jan. 22	1854	Apr. 11	Jan. 28	1883	Apr. 22	Jan. 26
1825	Apr. 1	Feb. 9	1855	Apr. 20	Feb. 4	1884	Apr. 19	Jan. 8
1826	Mar. 24	Feb. 1	1856	Apr. 18	Jan. 22	1885	Apr. 25	Jan. 29
1827	Mar. 31	Jan. 21	1857	Apr. 9	Jan. 15	1886	Apr. 15	Jan. 24
1828	Open.	Open.	1858	Apr. 6	Feb. 12	1887	Jan. 12 Apr. 27	Jan. 9 Feb. 13
1829	Apr. 4	Jan. 13	1859	Apr. 2	Jan. 11			
1830	Apr. 12	Jan. 15	1860	Apr. 2	Feb. 2	1888	Apr. 22	Jan. 22
1831	Apr. 10	Jan. 16	1861	Apr. 14	Jan. 23	1889	Mar. 27	Feb. 7
1832	Apr. 17	Feb. 6	1862	Apr. 23	Feb. 5	1890	Feb. 11 Feb. 28 Mar. 12	Feb. 10 Feb. 21 Mar. 7
1833	Apr. 6	Feb. 2	1863	Apr. 26	Feb. 4			
1834	Apr. 21	Apr. 14	1864	Mar. 13	Feb. 17			
1835	Apr. 12	Jan. 10	1865	Apr. 5	Jan. 17	1891	Jan. 31 Feb. 27 Apr. 2	Jan. 27 Feb. 14 Mar. 8
1836	Apr. 21	Jan. 27	1866	Apr. 11	Jan. 30			
1837	Apr. 28	Jan. 15	1867	Apr. 8	Jan. 20			
1838	Apr. 13	Feb. 2	1868	Apr. 15	Jan. 7	1892	Apr. 3	Feb. 14
1839	Apr. 6	Jan. 25	1869	Apr. 20	Jan. 19	1893	Apr. 9	Jan. 16
1840	Feb. 20	Jan. 25	1870	Apr. 12	Feb. 25	1894	Feb. 15	Feb. 6
1841	Apr. 26	Feb. 18	1871	Mar. 12	Jan. 24	1895	Apr. 17	Feb. 7
1842	Open.	Open.	1872	Apr. 22	Jan. 8	1896	Apr. 30	Feb. 17
1843	Apr. 23	Feb. 26	1873	Apr. 25	Jan. 29			
1844	Apr. 11	Jan. 25	1874	Mar. 27	Feb. 1			

Average date of opening, April 1; average date of closing, January 26; average number of days closed, 64.

Authorities: Mr. Charles E. Allen and Mr. Thomas H. Canfield.

No. 63.—LAKE PEPIN, LAKE CITY, MINN.

[44° 30′ latitude north. 92° 26′ longitude west.]

Year.	Opened.	Closed.	Year.	Opened.	Closed.	Year.	Opened.	Closed.
1849	Apr. 9	.....	1866	Apr. 19	Dec. 4	1883	Apr. 11	Nov. 15
1850	Apr. 10	.....	1867	Apr. 19	Nov. 29	1884	Apr. 16	Nov. 19
1851	Apr. 1	.....	1868	Apr. 4	Dec. 1	1885	Apr. 21	.....
1852	Apr. 16	.....	1869	Apr. 20	Nov. 19	1886	Apr. 14	Nov. 24
1853	Apr. 11	.....	1870	Apr. 15	Dec. 16	1887	Apr. 15	Nov. 27
1854	Apr. 8	.....	1871	Apr. 17	Nov. 21	1888	Apr. 22	Dec. 17
1855	Apr. 17	.....	1872	Apr. 25	Nov. 19	1889	Apr. 3	.....
1856	Apr. 18	.....	1873	Apr. 17	Nov. 14	1890	.....	Jan. 14
1857	May 1	.....	1874	Apr. 22	Nov. 24	1890	Apr. 15	Dec. 3
1858	Mar. 25	.....	1875	Apr. 20	Nov. 19	1891	Apr. 17	Nov. 23
1859	Apr. 19	.....	1876	Apr. 22	Nov. 27	1892	Apr. 6	Nov. 21
1860	Apr. 7	Nov. 24	1877	Apr. 16	Nov. 29	1893	Apr. 14	Nov. 24
1861	Apr. 7	Nov. 27	1878	Mar. 9	Dec. 6	1894	Mar. 24	Nov. 19
1862	Apr. 8	Nov. 28	1879	Apr. 4	Dec. 9	1895	Apr. 8	Nov. 23
1863	Apr. 5	Nov. 28	1880	Apr. 10	Nov. 18	1896	Apr. 13	.....
1864	Apr. 14	Nov. 21	1881	Apr. 3	Nov. 22			
1865	Apr. 15	Dec. 4	1882	Apr. 6	Nov. 2			

Average date of opening, April 12; average date of closing, November 25; average number of days closed, 138.

Authority: Dr. D. C. Estes, Lake City, Minn.

No. 64.—LAKE SIMCOE, KEMPENFELDT BAY.

[44° 23′ latitude north. Altitude, 714 feet. 78° 43′ longitude west.]

Year.	Opened.	Closed.	Year.	Opened.	Closed.	Year.	Opened.	Closed.
1852	.....	Dec. 31	1869	Apr. 29	Dec. 6	1885	May 6	Dec. 26
1853	Apr. 27	Dec. 28	1870	Apr. 25	.....	1886	Apr. 23	Dec. 23
1854	.....	Dec. 21	1871	.....	Jan. 5	1887	Apr. 30	Dec. 24
1855	Apr. 26	Dec. 25	1871	Apr. 10	Dec. 13	1888	May 1	.....
1856	Apr. 27	Dec. 16	1872	May 2	Dec. 11	1889	.....	Jan. 19
1857	May 5	Dec. 26	1873	May 5	Dec. 15	1889	Apr. 19	.....
1858	Apr. 17	Dec. 17	1874	May 9	Dec. 30	1890	.....	Jan. 14
1859	Apr. 26	Dec. 13	1875	May 8	Dec. 1	1890	Apr. 17	Dec. 24
1860	Apr. 12	Dec. 13	1876	May 1	Dec. 17	1891	Apr. 22	.....
1861	Apr. 24	.....	1877	Apr. 24	Dec. 31	1892	.....	Jan. 3
1862	.....	Dec. 19	1878	Mar. 30	Dec. 27	1892	Apr. 10	Dec. 25
1863	Apr. 23	Dec. 19	1879	Apr. 29	Dec. 24	1893	Apr. 22	Dec. 13
1864	Apr. 26	Dec. 22	1880	Apr. 15	Dec. 9	1894	Apr. 13	Dec. 27
1865	Apr. 12	Dec. 27	1881	Apr. 27	Dec. 19	1895	Apr. 22	.....
1866	Apr. 21	Dec. 20	1882	Apr. 13	Dec. 16	1896	.....	Jan. 4
1867	Apr. 30	Dec. 12	1883	May 5	Dec. 29	1896	Apr. 19	.....
1868	Apr. 17	.....	1884	May 6	Dec. 19			

Average date of opening, April 24; average date of closing, December 22; average number of days closed, 123.

Authorities: Hon. Judge Ardagh; The Barrie Examiner, Barrie, Ontario.

No. 65.—LAKE ST. FRANCIS, CANADA.

[Altitude, 153.50 feet.]

Year.	Opened.	Closed.	Year.	Opened.	Closed.	Year.	Opened.	Closed.
1886	.....	.....	1891	.....	.....	1895	Apr. 15	Dec. 14
1887	.....	.....	1892	.....	Jan. 11	1895	Dec. 20	.....
1888	.....	.....	1892	.....	Dec. 26	1896	.....	Jan. 4
1889	.....	.....	1893	Apr. 14	Dec. 14	1896	Apr. 16	.....
1890	.....	.....	1894	Apr. 1	Dec. 28			

Average date of opening, April 12; average date of closing, December 24; Average number of days closed, 109.

Authority: Mr. F. Gourdeau, Deputy Minister of Marine and Fisheries, Dominion of Canada.

NOTE.—Compared with Rouses Point, N. Y., for interpolation for twenty years' period.

No. 66.—LANCASTER PIER LIGHT-HOUSE, LANCASTER, ONTARIO.

Year.	Opened.	Closed.	Year.	Opened.	Closed.	Year.	Opened.	Closed.
1862	.....	Dec. 2	1874	Apr. 28	Nov. 29	1886	May 1	Dec. 2
1863	Apr. 28	Dec. 9	1875	May 3	Nov. 27	1887	May 4	Nov. 30
1864	Apr. 23	Dec. 9	1876	May 1	Dec. 4	1888	May 1	Nov. 25
1865	Apr. 24	Dec. 9	1877	Apr. 30	Dec. 2	1889	Apr. 22	Nov. 30
1866	Apr. 30	Dec. 9	1878	Apr. 17	Dec. 3	1890	Apr. 17	Nov. 30
1867	Apr. 28	Nov. 27	1879	May 1	Nov. 30	1891	Apr. 28	Dec. 1
1868	Apr. 27	Dec. 2	1880	Apr. 22	Nov. 25	1892	Apr. 22	Dec. 3
1869	May 5	Nov. 25	1881	Apr. 26	Nov. 27	1893	May 1	Dec. 4
1870	Apr. 27	Dec. 9	1882	Apr. 24	Nov. 30	1894	Apr. 23	Nov. 30
1871	Apr. 19	Nov. 30	1883	May 1	Nov. 30	1895	Apr. 29	Nov. 30
1872	May 1	Dec. 2	1884	Apr. 26	Nov. 29	1896	May 1	.....
1873	Apr. 28	Nov. 26	1885	May 6	Dec. 1			

Average date of opening, April 27; Average date of closing, December 1; average number of days closed, 147.

Authority: Mr. F. Gourdeau, deputy minister marine and fisheries, Dominion of Canada.

No. 67.—LEAVENWORTH, KANS.

[39° 18′ latitude north. Altitude, 742 feet. 94° 57′ longitude west.]

Year.	Opened.	Closed.	Year.	Opened.	Closed.	Year.	Opened.	Closed.
1871	.....	.....	1882	Jan. 21	.....	1891	Mar. 12	.....
1872	Feb. 20	.....	1883	.....	Jan. 9	1892	.....	Jan. 7
1873	.....	.....	1883	Feb. 25	Dec. 31	1892	Jan. 31	Dec. 27
1874	Feb. 1	.....	1884	Feb. 25	Dec. 18	1893	Feb. 27	Dec. 3
1875	.....	Jan. 5	1885	Mar. 10	.....	1893	Dec. 15	.....
1875	Mar. 14	.....	1886	.....	Jan. 7	1894	.....	Jan. 13
1876	.....	Feb. 4	1886	Feb. 20	Dec. 26	1894	.....	Feb. 28
1876	Feb. 8	Dec. 31	1887	Feb. 17	Dec. 20	1894	Jan. 18	.....
1877	Feb. 9	.....	1888	Feb. 19	.....		Feb. 28	Dec. 28
1878	.....	Jan. 4	1889	.....	Feb. 24	1895	Dec. 12	Dec. 3
1878	Mar. 27	Dec. 18	1889	Mar. 4	Open.	1895	Feb. 25	.....
1879	Feb. 10	Dec. 14	1890	Open.	.....	1896	.....	Jan. 3
1880	Jan. 6	Dec. 6	1891	.....	Feb. 3	1896	Jan. 20	.....
1881	Mar. 14	Dec. 30						

Average date of opening, February 18; average date of closing, January 7; average number of days closed, 42.

Authorities: United States Weather Bureau, 1896; Missouri River Commission, "Stages of the Missouri River," 1894.

No. 68.—LITTLE TRAVERSE LIGHT-HOUSE, MICHIGAN.

[45° 25′ latitude north. Altitude, 579.60 feet. 84° 58′ longitude west.]

Year.	Opened.	Closed.	Year.	Opened.	Closed.	Year.	Opened.	Closed.
1887	Apr. 29	Dec. 12	1891	Apr. 15	Dec. 22	1894	Apr. 7	Dec. 17
1888	Apr. 30	Dec. 12	1892	Apr. 5	Dec. 17	1895	Apr. 16	Dec. 13
1889	Apr. 12	Dec. 14	1893	Apr. 14	Dec. 12	1896	Apr. 14	.....
1890	Apr. 9	Dec. 18						

Average date of opening, April 14; average date of closing, December 15; average number of days closed, 120.

Authority: Commander J. H. Dayton, U. S. N., Ninth light-house district.

NOTE.—Compared with Alpena, Mich., for interpolation for twenty years' period.

No. 69.—LONG TAIL POINT LIGHT-HOUSE, WISCONSIN.

[44° 36′ latitude north. Altitude, 579.60 feet. 87° 59′ longitude west.]

Year.	Opened.	Closed.	Year.	Opened.	Closed.	Year.	Opened.	Closed.
1887	Apr. 23	Nov. 27	1891	Apr. 22	Dec. 6	1895	Apr. 15	Dec. 7
1888	Apr. 28	Dec. 12	1892	Apr. 5	Dec. 7	1896	Apr. 5	.....
1889	Apr. 1	Dec. 3	1893	Apr. 13	Dec. 3			
1890	Apr. 11	Dec. 4	1894	Mar. 19	Dec. 10			

Average date of opening, April 10; average date of closing, December 5; average number of days closed, 126.

Authority: Commander J. H. Dayton, U. S. N., Ninth light-house district.

NOTE.—Compared with Green Bay, Wis., for interpolation for twenty years' period.

No. 70.—LOUISVILLE, KY.

[38° 15′ latitude north. Altitude, 394.45 feet. 85° 45′ longitude west.]

Year.	Opened.	Closed.	Year.	Opened.	Closed.	Year.	Opened.	Closed.
1846	.....	Open.	1864	Open.	Open.	1881	Jan. 31	Open.
1847	Open.	[Closed	1865	Open.	Open.	1882	Open.	[Closed
1848	10 days]	Open.	1866	Open.	Open.	1883	6 days]	[Closed
1849	Open.	Open.	1867	Open.	Open.	1884	22 days	[Closed
1850	Open.	Open.	1868	Open.	Open.	1885	22 days	[Closed
1851	Open.	Dec. 17	1869	Open.	Open.	1886	23 days	[Closed
1852	Jan. 28	Open.	1870	Open.	[Closed	1887	27 days	[Closed
1853	Open.	[Closed	1871	21 days	[Closed	1888	6 days]	Open.
1854	12 days]	Open.	1872	35 days	[Closed	1889	Open.	Open.
1855	Open.	[Closed	1873	21 days]	Open.	1890	Open.	Open.
1856	61 days]	[Closed	1874	Open.	.....	1891	Open.	[Closed
1857	49 days]	Open.	1875	.....	Jan. 10	1892	8 days]	[Closed
1858	Open.	Open.	1875	Feb. 21	Open.	1893	44 days]	Open.
1859	Open.	Open.	1876	Open.	Dec. 9	1894	Open.	[Closed
1860	Open.	Open.	1877	Jan. 13	Open.	1895	43 days]	Open.
1861	Open.	Open.	1878	Open.	[Closed	1896	Open.	.....
1862	Open.	Open.	1879	30 days]	Open.			
1863	Open.	Open.	1880	Open.	Dec. 28			

Average number of days closed, 11.5.

Authority: Col. W. W. Hite, president Louisville and Evansville Mail Company.

No. 71.—MACKINAW CITY, MICH.

[45° 52′ latitude north. Altitude, 579.6 feet. 84° 52′ longitude west.]

Year.	Opened.	Closed.	Year.	Opened.	Closed.	Year.	Opened.	Closed.
1871	Apr. 2	.....	1882	Apr. 5	.....	1890	Apr. 9	Dec. 24
1872	Apr. 28	.....	1883	.....	Jan. 14	1891	Apr. 16	Dec. 15
1873	May 1	.....	1883	Apr. 25	Dec. 22	1892	Mar. 31	.....
1874	Apr. 29	Nov. 28	1884	Apr. 24	.....	1893	.....	Jan. 4
1875	Apr. 28	.....	1885	.....	Jan. 3	1893	Apr. 19	.....
1876	Apr. 28	(Dec. 27)	1885	May 1	.....	1894	.....	Jan. 28
1877	Apr. 20	.....	1886	.....	Jan. 6	1894	Mar. 11	.....
1878	.....	(Jan. 23)	1886	Apr. 21	Dec. 27	1895	.....	Feb. 2
1878	Mar. 14	(Dec. 25)	1887	Apr. 24	.....	1895	Apr. 6	.....
1879	Apr. 23	.....	1888	.....	Jan. 2	1896	.....	Jan. 21
1880	.....	Jan. 15	1888	May 4	Dec. 18	1896	Apr. 16	.....
1880	Apr. 5	Dec. 15[a]	1889	Mar. 27	.....			
1881	Apr. 28	Dec. 15	1890	.....	Jan. 4			

[a] Mail carried across the ice December 22.

Average date of opening, April 15; average date of closing, December 31; average number of days closed, 105.

Authorities: United States Weather Bureau, 1896; Mr. Geo. W. Marshall, keeper Old Mackinaw Point light-house; Mr. James Davenport, keeper McGulpin Point light-house.

NOTE.—Compared with Alpena, Mich., for interpolation for twenty years' period.

No. 72.—MANKATO, MINN.

[44° 08′ latitude north. Altitude, 756 feet. 94° 00′ longitude west.]

Year.	Opened.	Closed.	Year.	Opened.	Closed.	Year.	Opened.	Closed.
1855	Apr. 10	Nov. 26	1869	Apr. 12	Nov. 27	1883	Apr. 13	Nov. 13
1856	Apr. 11	Nov. 17	1870	Apr. 8	Nov. 13	1884	Apr. 9	Nov. 19
1857	Apr. 24	Nov. 23	1871	Apr. 3	Nov. 27	1885	Apr. 14	Nov. 23
1858	Mar. 18	Nov. 23	1872	Apr. 16	Nov. 22	1886	Apr. 10	Nov. 17
1859	Apr. 13	Dec. 6	1873	Apr. 10	Nov. 19	1887	Apr. 13	Dec. 3
1860	Mar. 21	Nov. 30	1874	Apr. 16	Nov. 23	1888	Apr. 13	Dec. 29
1861	Apr. 1	Dec. 2	1875	Apr. 18	Nov. 24	1889	Mar. 30	Dec. 2
1862	Apr. 11	Nov. 22	1876	Apr. 15	Nov. 26	1890	Apr. 17	Dec. 9
1863	Mar. 30	Dec. 1	1877	Apr. 10	Dec. 4	1891	Mar. 23	Dec. 6
1864	Apr. 7	Nov. 18	1878	Apr. 13	Dec. 8	1892	Apr. 14	Nov. 28
1865	Apr. 8	Dec. 8	1879	Apr. 14	Nov. 1	1893	Apr. 23	Dec. 18
1866	Apr. 12	Nov. 30	1880	Apr. 7	Nov. 23	1894	Feb. 28	Dec. 6
1867	Apr. 14	Dec. 6	1881	Apr. 8	Nov. 25	1895	Mar. 14	Dec. 4
1868	Mar. 28	Nov. 8	1882	Apr. 3	Nov. 26	1896	Mar. 2	.....

Average date of opening, April 6; average date of closing, November 27; average number of days closed, 130.

Authority: This table is made from the table for St. Paul, using the statement of Mr. John C. Wise, postmaster at Mankato. "Usually we are from several days to a week later in closing, and as much earlier in opening here than at St. Paul."

No. 73.—MARQUETTE LIGHT-HOUSE, MICHIGAN.

[46° 33′ latitude north. 87° 22′ longitude west.]

Year.	Opened.	Closed.	Year.	Opened.	Closed.	Year.	Opened.	Closed.
1874.....	May 3	Dec. 12	1882.....	Apr. 18	Dec. 7	1890.....	Apr. 15	Dec. 21
1875.....	May 19	Dec. 6	1883.....	May 5	Dec. 5	1891.....	Apr. 27	Dec. 13
1876.....	May 10	Dec. 8	1884.....	Apr. 30	Dec. 20	1892.....	Apr. 18	Dec. 10
1877.....	Apr. 23	Dec. 5	1885.....	May 8	Dec. 2	1893.....	May 7	Dec. 5
1878.....	Apr. 2	Dec. 7	1886.....	Apr. 28	Dec. 6	1894.....	Apr. 17	Dec. 4
1879.....	May 1	Dec. 11	1887.....	May 1	Nov. 30	1895.....	Apr. 25	Dec. 10
1880.....	Apr. 21	Dec. 24	1888.....	May 10	Nov. 30	1896.....	Apr. 20	.....
1881.....	May 8	Dec. 5	1889.....	Apr. 7	Dec. 31			

Average date of opening, April 27; average date of closing, December 10; average number of days closed, 138.

Authority: Commander William Folger, U. S. N., Eleventh light-house district.

No. 74.—MARQUETTE, MICH.

[46° 34′ latitude north. Altitude, 600.69 feet. 87° 24′ longitude west.]

Year.	Opened.	Closed.	Year.	Opened.	Closed.	Year.	Opened.	Closed.
1864.....	May 8	.....	1875.....	May 20	Nov. 24	1886.....	Apr. 28	Dec. 1
1865.....	Apr. 28	.....	1876.....	May 12	Nov. 26	1887.....	May 5	Dec. 1
1866.....	May 9	.....	1877.....	May 5	Nov. 28	1888.....	May 11	Nov. 26
1867.....	May 6	.....	1878.....	Apr. 18	Nov. 26	1889.....	Apr. 21	Nov. 30
1868.....	May 3	.....	1879.....	May 8	Nov. 25	1890.....	Apr. 23	Dec. 3
1869.....	May 7	.....	1880.....	May 4	Nov. 29	1891.....	May 1	Dec. 2
1870.....	Apr. 30	.....	1881.....	May 11	Nov. 23	1892.....	Apr. 21	Dec. 6
1871.....	May 9	Nov. 22	1882.....	Apr. 25	Nov. 27	1893.....	May 7	Dec. 3
1872.....	May 13	Nov. 25	1883.....	May 5	Nov. 28	1894.....	Apr. 20	Dec. 4
1873.....	May 21	Nov. 22	1884.....	Apr. 30	Dec. 5	1895.....	Apr. 29	Dec. 8
1874.....	May 13	Nov. 27	1885.....	May 11	Dec. 2	1896.....	Apr. 22	.....

Average date of opening, May 3; average date of closing, November 28; average number of days closed, 156.

Authority: United States Weather Bureau, 1896.

No. 75.—MENOMINEE LIGHT-HOUSE, MICHIGAN.

[45° 06′ latitude north. Altitude, 579.60 feet. 87° 35′ longitude west.]

Year.	Opened.	Closed.	Year.	Opened.	Closed.	Year.	Opened.	Closed.
1887.....	Apr. 23	Dec. 23	1891.....	Apr. 15	Dec. 26	1894.....	Apr. 18	.....
1888.....	May 2	Dec. 27	1892.....	Apr. 6	Dec. 20	1895.....	.....	Jan. 31
1889.....	Apr. 4	Dec. 31	1893.....	Apr. 23	Dec. 12	1895.....	Apr. 1	Dec. 31
1890.....	Apr. 15	Dec. 21				1896.....	Apr. 8	.....

Average date of opening, April 14; average date of closing, December 28; average number of days closed, 107.

Authority: Commander J. H. Dayton, U. S. N., Ninth light-house district.

NOTE.—Compared with Green Bay, Wis., for interpolation for twenty years' period.

No. 76.—MEREDOSIA, ILL.

[39° 49′ latitude north. Altitude, 424.31 feet. 90° 37′ longitude west.]

Year.	Opened.	Closed.	Year.	Opened.	Closed.	Year.	Opened.	Closed.
1887.....	Feb. 16	Nov. 30	1891.....	Jan. 23	Dec. 10	1894.....	Mar. 1	Dec. 28
1888.....	Mar. 2	Dec. 12	1892.....	Feb. 6	Dec. 2	1895.....	Mar. 3	Dec. 3
1889.....	Mar. 8	Dec. 17	1893.....	Mar. 6	Dec. 1	1896.....	Feb. 18	.....
1890	Feb. 2	Dec. 1						

Average date of opening, February 19; average date of closing, December 7; average number of days closed, 74.

Authority: Mr. J. S. Goodrich, superintendent Wabash Railroad Company.

NOTE.—Compared with Peoria, Ill., for interpolation for twenty years' period.

No. 77.—MILWAUKEE, WIS.

[43° 02′ latitude north. Altitude, 579.6 feet. 87° 54′ longitude west.]

Year.	Opened.	Closed.	Year.	Opened.	Closed.	Year.	Opened.	Closed.
1871	Open.	Open.	1880	Open.	Open.	1889	Open.	Open.
1872	Open.	Open.	1881	Open.	Open.	1890	Open.	Dec. 5
1873	Open.	Open.	1882	Open.	Open.	1891	.....	Dec. 10
1874	Open.	Open.	1883	Open.	Open.	1892	Apr. 15	Dec. 10
1875	Open.	Open.	1884	Open.	Open.	1893	Apr. 13	Dec. 8
1876	Open.	Open.	1885	Open.	Open.	1894	Jan. 15	.....
1877	Open.	Open.	1886	Open.	Open.	1895	.....	Jan. 14
1878	Open.	Open.	1887	Open.	Open.	1895	Feb. 20	Open.
1879	Open.	Open.	1888	Open.	Open.	1896	Open.	.....

Average date of opening, March 10; average date of closing, February 24; average number of days closed, 14.

Authorities: United States Weather Bureau; Mr. M. J. Dunn, fire department.

No. 78.—MISSION POINT LIGHT-HOUSE, MICHIGAN.

[44° 59′ latitude north. 85° 28′ longitude west.]

Year.	Opened.	Closed.	Year.	Opened.	Closed.	Year.	Opened.	Closed.
1887	Apr. 22	Dec. 16	1891	Apr. 1	Dec. 17	1894	Mar. 16	Dec. 17
1888	Apr. 26	Dec. 19	1892	Apr. 1	Dec. 18	1895	Apr. 14	Dec. 15
1889	Apr. 1	Dec. 20	1893	Apr. 7	Dec. 15	1896	Apr. 6	.....
1890	Apr. 1	Dec. 15						

Average date of opening, April 5; average date of closing, December 17; average number of days closed, 109.

Authority: Commander J. H. Dayton, U. S. N., Ninth light-house district.

NOTE.—Compared with Escanaba, Mich., for interpolation for twenty years' period.

No. 79.—MONROE, MICH.—RAISIN RIVER.

[41° 52′ latitude north. Altitude, 571.35 feet. 83° 16′ longitude west.]

Year.	Opened.	Closed.	Year.	Opened.	Closed.	Year.	Opened.	Closed.
1876	Jan. 7	Dec. 9	1884	Mar. 19	Dec. 16	1891	Mar. 11	Dec. 18
1877	Mar. 22	Dec. 28	1885	Apr. 1	Dec. 5	1892	Mar. 1	Dec. 20
1878	Mar. 1	Dec. 22	1886	Mar. 9	Nov. 25	1893	Mar. 11	Dec. 2
1879	Mar. 9	Dec. 17	1887	Feb. 11	Dec. 22	1894	Mar. 5	Dec. 25
1880	Feb. 21	Dec. 6	1888	Mar. 20	Dec. 18	1895	Mar. 24	Dec. 7
1881	Mar. 15	Dec. 31	1889	Mar. 17	.....	1896	Mar. 21	.....
1882	Feb. 13	Dec. 8	1890	.....	Jan. 21			
1883	Mar. 18	Dec. 15	1890	Mar. 8	Dec. 4			

Average date of opening, March 7; average date of closing, December 13; average number of days closed, 94.

Authority: Lieut. Col. Jared A. Smith, United States Army Engineers.

No. 80.—MONTREAL, PROVINCE OF QUEBEC.

[45° 31′ latitude north. Altitude, 23.0 feet. 73° 33′ longitude west.]

Year.	Opened.	Closed.	Year.	Opened.	Closed.	Year.	Opened.	Closed.
1848	Apr. 12	Dec. 22	1865	Apr. 10	Dec. 16	1881	Apr. 21	.....
1849	Apr. 13	Dec. 7	1866	Apr. 19	Dec. 15	1882	.....	Jan. 2
1850	Apr. 15	Dec. 6	1867	Apr. 22	Dec. 6	1882	Apr. 11	Dec. 9
1851	Apr. 11	Dec. 9	1868	Apr. 17	Dec. 9	1883	Apr. 27	Dec. 16
1852	Apr. 25	Dec. 18	1869	Apr. 25	Dec. 6	1884	Apr. 22	Dec. 18
1853	Apr. 15	Dec. 15	1870	Apr. 18	Dec. 18	1885	May 5	Dec. 7
1854	Apr. 25	Dec. 6	1871	Apr. 8	Dec. 1	1886	Apr. 24	Dec. 4
1855	Apr. 28	Dec. 12	1872	May 1	Dec. 8	1887	May 1	Dec. 23
1856	Apr. 24	Dec. 3	1873	Apr. 25	Nov. 26	1888	Apr. 29	Dec. 14
1857	Apr. 18	Dec. 13	1874	Apr. 25	Dec. 13	1889	Apr. 14	Dec. 29
1858	Apr. 9	Dec. 12	1875	May 3	Nov. 29	1890	Apr. 14	Dec. 3
1859	Apr. 4	Dec. 11	1876	Apr. 27	Dec. 10	1891	Apr. 17	Dec. 17
1860	Apr. 10	Dec. 7	1877	Apr. 17	.....	1892	Apr. 13	Dec. 23
1861	Apr. 24	Dec. 22	1878	.....	Jan. 2	1893	Apr. 24	Dec. 4
1862	Apr. 23	Dec. 7	1878	Mar. 30	Dec. 23	1894	Apr. 12	Dec. 26
1863	Apr. 25	Dec. 12	1879	Apr. 24	Dec. 19	1895	Apr. 20	Dec. 5
1864	Apr. 13	Dec. 11	1880	Apr. 17	Dec. 3	1896	Apr. 22	.....

Average date of opening, April 20; average date of closing, December 13; average number of days closed, 128.

Authority: Mr. Alexander Robertson, secretary harbor commissioners.

No. 81.—MOORHEAD, MINN.

[46° 52′ latitude north. Altitude, 866 feet. 96° 44′ longitude west.]

Year.	Opened.	Closed.	Year.	Opened.	Closed.	Year.	Opened.	Closed.
1875	(Apr. 18)	Nov. 16	1883	Apr. 16	Nov. 17	1891	(Apr. 13)	(Nov. 21)
1876	Apr. 27	Nov. 4	1884	Apr. 19	Nov. 19	1892	(Apr. 18)	(Nov. 12)
1877	Apr. 20	(Dec. 4)	1885	Apr. 24	Nov. 25	1893	(Apr. 27)	(Nov. 22)
1878	(Mar. 15)	(Nov. 3)	1886	Apr. 12	(Nov. 27)	1894	(Apr. 16)	(Nov. 13)
1879	Apr. 6	(Nov. 5)	1887	Apr. 12	Oct. 26	1895	(Apr. 5)	(Nov. 9)
1880	Apr. 12	(Nov. 15)	1888	Apr. 26	Nov. 17	1896	Apr. 26	.....
1881	Apr. 23	Nov. 15	1889	Apr. 15	(Nov. 19)			
1882	Apr. 12	Nov. 11	1890	(Apr. 13)	(Dec. 4)			

Average date of opening, April 18; average date of closing, November 14; average number of days closed, 155.

Authority: United States Weather Bureau.

NOTE.—Compared with St. Vincent, Minn., for interpolation for twenty years' period.

No. 82.—MORRIS, ILL.—ILLINOIS RIVER.

[41° 23′ latitude north. 88° 25′ longitude west.]

Year.	Opened.	Closed.	Year.	Opened.	Closed.	Year.	Opened.	Closed.
1830	Mar.	.....	1856	Feb. 16	Dec. 2	1879	Mar. 8	(Dec. 23)
1834	.....	.....	1857	Mar. 14	Dec. 1	1880	Mar. 3	(Nov. 22)
1835	Feb. 1	.....	1858	Mar. 10	Mild.	1881	Mar. 5	(Open.)
1836	Mar. 20	Dec. 19	1859	Winter.	Open.	1882	Feb. 5	Jan. 16
1837	Mar. 20	.....	1860	Open.	.....	1883	Mar. 9	(Dec. 29)
1838	.....	.....	1861	.....	.....	1884	Mar. 20	(Jan. 18)
1839	.....	.....	1862	Mar. 10	Dec. 28	1885	Mar. 31	Open.
1840	.....	.....	1863	Mar. 1	Dec. 31	1886	Open.	Dec. 27
1841	.....	.....	1864	Mar.	.....	1887	Feb. 8	Feb. 15
1842	Mar. 12	Nov. 16	1865	Mar. 16	Dec. 1		Apr. 8	Nov. 20
1843	Apr. 9	.....	1866	Mar. 6	Dec. 2	1888	Feb. 26	.....
1844	Mar. 15	.....	1867	Feb. 26	.....	1889	.....	Jan. 12
1845	.....	.....	1868	Mar. 7	.....	1889	Mar. 15	(Open.)
1846	.....	Dec. 1	1869	.....	.....	1890	(Open.)	(Open.)
1847	Mar. 15	Dec.	1870	.....	.....	1891	(Feb. 7)	.....
1848	Mar. 17	.....	1871	Feb. 24	.....	1892	.....	(Jan. 19)
1849	Mar. 7	.....	1872	Mar. 10	.....	1892	(Feb. 4)	(Dec. 30)
1850	Mar. 11	Dec.	1873	.....	.....	1893	(Mar. 8)	(Dec. 8)
1851	Mar. 5	.....	1874	.....	.....	1894	(Feb. 9)	.....
1852	.....	.....	1875	Mar. 29	.....	1895	.....	(Jan. 8)
1853	Mar. 10	.....	1876	.....	Open.	1895	(Mar. 1)	.....
1854	Mar. 1	.....	1877	Open.	Open.	1896	.....	(Jan. 8)
1855	Mar. 8	.....	1878	Open.	(Dec. 24)	1896	(Feb. 28)	.....

Average date of opening, March 10; average date of closing, January 6; average number of days closed, 68.

Authority: L. W. Claypoole.

NOTE.—Compared with Seneca, Ill., for interpolation for twenty years' period.

No. 83.—NEBRASKA CITY, NEBR.

[40° 40′ latitude north. Altitude, 907 feet. 95° 51′ longitude west.]

Year.	Opened.	Closed.	Year.	Opened.	Closed.	Year.	Opened.	Closed.
1863	Mar. 1	Feb. 2 Dec. 12	1876	Open.	Nov. 30	1890	Feb. 10 Mar. 17	Jan. 4 Feb. 20
1864	Feb. 22	Dec. 10	1877	Feb. 16	.....	1891	Mar. 17	Feb. 3
1865	Feb. 20	Dec. 8	1878	Jan. 19	Dec. 18	1892	Feb. 25	Jan. 2 Dec. 9
1866	Feb. 28	Dec. 10	1879	Mar. 6	Dec. 11	1893	Mar. 10 Dec. 25	Dec. 2
1867	Apr. 2	Dec. 18	1880	Jan. 11	Nov. 19	1894	Mar. 3	Jan. 24 Dec. 28
1868	Feb. 23	Dec. 9	1881	Mar. 24	Dec. 18	1895	Feb. 27 Dec. 16	Dec. 2
1869	Feb. 28	Dec. 24	1882	Feb. 11	Dec. 8	1896	Open.	....
1870	Feb. 15	Dec. 21	1883	Mar. 4	Dec. 19			
1871	Feb. 22	Nov. 26	1884	Mar. 15	Dec. 18			
1872	Feb. 24	Nov. 23	1885	Mar. 9	Dec. 7			
1873	Mar. 3	Dec. 3	1886	Mar. 17	Dec. 5			
1874	Mar. 16	Nov. 28	1887	Mar. 9	Nov. 27			
1875	Mar. 25 Dec. 22	Nov. 22	1888	Mar. 17	Open.			
			1889	Mar. 1	Jan. 13			

Average date of opening, February 27; average date of closing, December 14; average number of days closed, 75.

Authority: The Nebraska City News, December 20, 1895.

No. 84.—OGDENSBURG, N. Y.

[44° 43′ latitude north. Altitude, 244.28 feet. 75° 30′ longitude west.]

Year.	Opened.	Closed.	Year.	Opened.	Closed.	Year.	Opened.	Closed.
1833	Apr. 12	Dec. 21	1855	Apr. 21	Dec. 17	1877	Apr. 10	.....
1834	Apr. 2	Dec. 17	1856	Apr. 29	Dec. 22	1878	Mar. 21	Dec. 12
1835	Apr. 4	Nov. 28	1857	Apr. 25	Dec. 29	1879	Apr. 19	Dec. 18
1836	Apr. 20	Dec. 7	1858	Apr. 8	Dec. 7	1880	Apr. 1	Dec. 14
1837	Apr. 20	Dec. 20	1859	Apr. 12	Dec. 17	1881	Mar. 26	Dec. 25
1838	Apr. 12	Dec. 7	1860	Apr. 9	Dec. 18	1882	Mar. 28	Dec. 15
1839	Apr. 11	Dec. 26	1861	Apr. 12	Dec. 9	1883	Apr. 13	Dec. 18
1840	Apr. 1	Dec. 9	1862	Apr. 11	Dec. 13	1884	Apr. 7	Dec. 6
1841	Apr. 16	Dec. 8	1863	Apr. 14	Dec. 11	1885	Apr. 23	Dec. 14
1842	Mar. 24	Dec. 1	1864	Apr. 18	Dec. 16	1886	Apr. 10	Dec. 15
1843	May 3	Dec. 20	1865	Apr. 13	Dec. 16	1887	Apr. 15	Dec. 17
1844	Apr. 6	Dec. 16	1866	Apr. 11	Dec. 17	1888	Apr. 11	Dec. 20
1845	Apr. 1	Dec. 15	1867	Apr. 17	Dec. 10	1889	Apr. 1	Dec. 18
1846	Apr. 6	Dec. 25	1868	Apr. 1	Dec. 19	1890	Apr. 1	Dec. 15
1847	Apr. 20	Dec. 8	1869	Apr. 14	Dec. 23	1891	Apr. 4	Dec. 20
1848	Apr. 4	Dec. 25	1870	Apr. 11	Dec. 20	1892	Apr. 8	Dec. 18
1849	Apr. 14	Dec. 21	1871	Mar. 21	.....	1893	Apr. 8	Dec. 13
1850	Mar. 30	Dec. 12	1872	Apr. 17	.....	1894	Apr. 1	Dec. 15
1851	Apr. 5	Dec. 16	1873	Apr. 15	.....	1895	Apr. 3	Dec. 15
1852	Apr. 5	Dec. 25	1874	Mar. 31	.....	1896	Apr. 10	.....
1853	Apr. 4	Dec. 21	1875	Apr. 27	.....			
1854	Apr. 13	Dec. 13	1876	Apr. 14	.....			

Average date of opening, April 10; average date of closing, December 15; average number of days closed, 116.

Authorities: Fifth Annual Report of the State Weather Bureau, New York; Mr. William Petus, special deputy collector.

No. 85.—OMAHA, NEBR.

[41° 16′ latitude north. Altitude, 960 feet. 95° 56′ longitude west.]

Year.	Opened.	Closed.	Year.	Opened.	Closed.	Year.	Opened.	Closed.
1872	Apr. 10	.....	1881	Apr. 13	.....	1889	Mar. 4	Nov. 28
1873	Mar. 10	Dec. 4	1882	.....	Jan. 2	1890	Mar. 19	Dec. 8
1874	Mar. 19	Nov. 22	1882	Mar. 10	Dec. 1	1891	Mar. 22	....
1875	Mar. 30	Nov. 23	1883	Mar. 9	Dec. 29	1892	.....	Feb. 4
1876	Apr. 3	Nov. 24	1884	Apr. 5	Dec. 17	1892	Feb. 26	Dec. 10
1877	Mar. 2	.....	1885	Apr. 14	Dec. 9	1893	Mar. 12	Dec. 1
1878	.....	Jan. 4	1886	Mar. 17	Nov. 30	1894	Mar. 4	.....
1878	Feb. 19	Dec. 18	1887	Mar. 12	Nov. 20	1895	.....	Jan. 4
1879	Mar. 9	Dec. 10	1888	Mar. 16	.....	1895	Feb. 28	Dec. 2
1880	Apr. 5	Dec. 28	1889	.....	Jan. 18	1896	Feb. 25	.....

Average date of opening, March 16; average date of closing, December 14; average number of days closed, 92.

Authorities: United States Weather Bureau, 1896; Mr. Lucius A. Welsh, observer, Weather Bureau, Omaha.

No. 86.—OSHKOSH, WIS.—LAKE WINNEBAGO.

[44° 02′ latitude north. Altitude, 750 feet. 88° 32′ longitude west.]

Year.	Opened.	Closed.	Year.	Opened.	Closed.	Year.	Opened.	Closed.
1869	Apr. 20	Nov. 17	1879	Apr. 17	.....	1889	Apr. 5	Nov. 28
1870	Apr. 14	Nov. 14	1880	Mar. 30	Nov. 16	1890	Apr. 11	Dec. 2
1871	Apr. 12	.....	1881	May 2	Nov. 24	1891	Apr. 18	Nov. 27
1872	.....	Nov. 16	1882	Mar. 19	Nov. 23	1892	Apr. 12	Nov. 19
1873	.....	.....	1883	Apr. 11	Nov. 20	1893	Apr. 10	Nov. 11
1874	Apr. 21	Nov. 23	1884	Apr. 22	Nov. 24	1894	Apr. 5	Nov. 19
1875	.....	.....	1885	Apr. 27	Nov. 28	1895	Apr. 15	Nov. 22
1876	.....	.....	1886	Apr. 21	Nov. 19	1896	Apr. 13	.....
1877	Apr. 26	Nov. 28	1887	Apr. 21	Nov. 21			
1878	Apr. 6	Nov. 26	1888	Apr. 21	Nov. 17			

Average date of opening, April 14; average date of closing, November 22; average number of days closed, 143.

Authority: The Cook and Brown Lime Company, Oshkosh, Wis.

No. 87.—OSWEGO, N. Y.—LAKE ONTARIO.

[43° 29′ latitude north. Altitude, 244.53 feet. 76° 35′ longitude west.]

Year.	Opened.	Closed.	Year.	Opened.	Closed.	Year.	Opened.	Closed.
1835	Apr. 2	.....	1855	Jan. 3	.....	1877	Apr. 14	Dec. 26
1836	Apr. 16	.....		Feb. 13	.....	1878	Mar. 11	Dec. 10
1837	Apr. 1	.....	1856	Apr. 19	.....	1879	Apr. 9	Dec. 16
1838	Apr. 6	.....	1857	Apr. 6	.....	1880	Mar. 10	.....
1839	Apr. 3	.....	1858	Apr. 1	.....	1881	.....	Jan. 24
1840	Apr. 4	.....	1859	Apr. 1	.....	1881	Apr. 2	Dec. 11
1841	Apr. 6	.....	1860	Mar. 9	Dec. 13	1882	Mar. 22	Dec. 5
1842	Mar. 7	.....	1861	Apr. 1	Dec. 23	1883	Apr. 6	Dec. 11
1843	Apr. 8	.....	1862	Apr. 2	Dec. 22	1884	Apr. 5	Dec. 13
1844	Mar. 15	.....	1863	Apr. 2	Dec. 15	1885	May 2	Dec. 16
1845	Mar. 28	.....	1864	Apr. 5	Dec. 21	1886	Apr. 1	Dec. 19
1846	Mar. 24	.....	1865	Apr. 1	Dec. 21	1887	Apr. 9	Dec. 16
1847	Mar. 25	.....	1866	Mar. 17	Dec. 15	1888	Apr. 14	Dec. 11
1848	Jan. 8	.....	1867	Apr. 6	Dec. 11	1889	Apr. 4	Dec. 18
	Apr. 3	.....	1868	Apr. 1	Dec. 12	1890	Mar. 25	.....
1849	Mar. 28	.....	1869	Apr. 10	Dec. 20	1891	.....	Jan. 17
1950	Mar. 21	.....	1870	Apr. 6	Dec. 19	1891	Apr. 4	Dec. 28
1851	Mar. 20	.....	1871	Mar. 20	Dec. 13	1892	Apr. 5	Dec. 21
1852	Apr. 1	.....	1872	Apr. 13	Dec. 12	1893	Apr. 5	Dec. 11
1853	Jan. 19	.....	1873	Apr. 7	Dec. 6	1894	Mar. 30	Dec. 18
	Mar. 12	.....	1874	Mar. 31	Dec. 4	1895	Apr. 19	Dec. 19
1854	Jan. 18	.....	1875	Apr. 13	Dec. 9	1896	Apr. 14	.....
	Feb. 27	.....	1876	Apr. 5	Dec. 28			

Average date of opening, April 4; average date of closing, December 17; average number of days closed, 108.

Authorities: Fifth Annual Report of the State Weather Bureau, 1894; United States Weather Bureau, 1896; Mr. Allen W. Poucher, special deputy collector; New York Meterology, 1850–1863, second series, by F. B. Hough.

NOTE.—The river at Oswego seldom freezes, except when the floating ice gets lodged for a few days at a time in midwinter, and occasionally vessels arrive and depart in all the winter months. The spring of 1856 was exceptionally late, and on the 10th of April teams crossed the river near its mouth, and the lake was frozen as far as could be seen. A propeller that left the harbor on the 19th was three days in sight.

No. 88.—OTTAWA RIVER, OTTAWA, ONTARIO.

[45° 16′ latitude north. Altitude, 131 feet. 75° 42′ longitude west.]

Year.	Opened.	Closed.	Year.	Opened.	Closed.	Year.	Opened.	Closed.
1846	Apr. 13	Nov. 27	1863	Apr. 26	Nov. 30	1880	Apr. 26	Nov. 22
1847	May 3	Nov. 20	1864	Apr. 20	Dec. 1	1881	Apr. 26	Nov. 19
1848	Apr. 12	Nov. 29	1865	Apr. 10	Dec. 1	1882	Apr. 27	Nov. 28
1849	Apr. 26	Dec. 3	1866	Apr. 23	Dec. 1	1883	Apr. 27	Nov. 24
1850	Apr. 28	Dec. 4	1867	Apr. 25	Nov. 30	1884	May 2	Nov. 22
1851	Apr. 14	Nov. 23	1868	Apr. 25	Nov. 19	1885	May 7	Nov. 26
1852	Apr. 28	Nov. 24	1869	Apr. 27	Nov. 18	1886	Apr. 26	Nov. 27
1853	Apr. 30	Nov. 30	1870	Apr. 18	Nov. 30	1887	Apr. 28	Nov. 24
1854	Apr. 27	Dec. 2	1871	Apr. 11	Nov. 27	1888	Apr. 30	Nov. 23
1855	Apr. 23	Nov. 21	1872	Apr. 27	Nov. 26	1889	Apr. 26	Nov. 29
1856	Apr. 27	Nov. 30	1873	Apr. 22	Nov. 16	1890	Apr. 20	Nov. 24
1857	Apr. 26	Nov. 25	1874	May 6	Nov. 15	1891	Apr. 26	Nov. 26
1858	Apr. 17	Nov. 26	1875	May 1	Nov. 20	1892	Apr. 28	Nov. 24
1859	Apr. 18	Nov. 28	1876	May 1	Nov. 30	1893	Apr. 27	Nov. 26
1860	Apr. 25	Nov. 26	1877	Apr. 20	Dec. 1	1894	Apr. 23	Nov. 22
1861	Apr. 24	Dec. 2	1878	Apr. 16	Nov. 30	1895	Apr. 19	Nov. 21
1862	Apr. 26	Nov. 24	1879	May 3	Nov. 26	1896	Apr. 27	.....

Average date of opening, April 25; average date of closing, November 26; average number of days closed, 150.

Authorities: Mr. F. Gourdeau, deputy minister marine and fisheries, Canada; Mr. R. W. Shepherd, managing director Ottawa River Navigation Company.

No. 89.—OTSEGO LAKE, COOPERSTOWN, N. Y.

[42° 50′ latitude north. Altitude, 1,300 feet. 74° 54′ longitude west.]

Year.	Opened.	Closed.	Year.	Opened.	Closed.	Year.	Opened.	Closed.
1841	Apr. 25	.....	1863	Apr. 23	.....	1881	Apr. 25	.....
1842	Mar. 30	.....	1864	.....	Jan. 3	1882	.....	Jan. 5
1843	Apr. 26	.....	1864	Apr. 21	.....	1882	Apr. 6	.....
1844	Apr. 13	.....	1865	.....	Jan. 8	1883	.....	Jan. 6
1845	Apr. 1	.....	1865	Apr. 5	.....	1883	Apr. 26	.....
1846	Apr. 7	.....	1866	.....	Jan. 7	1884	.....	Jan. 6
1847	Apr. 25	.....	1866	Apr. 14	.....	1884	Apr. 22	.....
1848	Apr. 10	.....	1867	.....	Jan. 3	1885	.....	Jan. 19
1849	Apr. 7	.....	1867	Apr. 15	.....	1885	Apr. 26	.....
1850	.....	Feb. 1	1868	.....	Jan. 6	1886	.....	Jan. 11
1850	Apr. 24	Dec. 30	1868	Apr. 16	Dec. 27	1886	Apr. 14	.....
1851	Mar. 30	Dec. 24	1869	Apr. 21	.....	1887	.....	Jan. 2
1852	Apr. 26	.....	1870	.....	Jan. 8	1887	Apr. 28	Dec. 30
1853	.....	Jan. 17	1870	Apr. 16	.....	1888	Apr. 30	.....
1853	Apr. 9	.....	1871	.....	Jan. 4	1889	.....	Jan. 19
1854	.....	Jan. 24	1871	.....	Dec. 21	1889	Apr. 11	.....
1854	Apr. 20	Dec. 20	1872	Apr. 27	Dec. 24	1890	.....	Feb. 22
1855	Apr. 24	.....	1873	May 4	.....	1890	Apr. 8	Dec. 25
1856	.....	Jan. 5	1874	.....	Jan. 26	1891	Apr. 15	.....
1856	Apr. 26	Dec. 18	1874	May 5	Dec. 31	1892	.....	Jan. 20
1857	Apr. 6	.....	1875	May 7	.....	1892	Apr. 5	Dec. 28
1858	.....	Feb. 5	1876	.....	Jan. 13	1893	Apr. 17	.....
1858	Apr. 5	.....	1876	Apr. 26	Dec. 17	1894	.....	Jan. 13
1859	.....	Jan. 9	1877	Apr. 27	.....	1894	Mar. 22	Dec. 29
1859	Mar. 30	Dec. 28	1878	.....	Jan. 29	1895	Apr. 19	.....
1860	Apr. 7	.....	1878	Apr. 1	.....	1896	.....	Jan. 6
1861	.....	Jan. 8	1879	.....	Jan. 3	1896	Apr. 18	.....
1861	Apr. 14	.....	1879	Apr. 30	.....			
1862	.....	Jan. 5	1880	.....	Feb. 3			
1862	Apr. 22	.....	1880	Apr. 7	Dec. 29			
1863	.....	Jan. 17						

Average date of opening, April 17; average date of closing, January 7; average number of days closed, 100.

Authority: Mr. G. Pomeroy Keese.

No. 90.—OUTER ISLAND LIGHT-HOUSE, NEAR ASHLAND, WIS.

[46° 56′ latitude north. Altitude, 600.69 feet. 90° 25′ longitude west.]

Year.	Opened.	Closed.	Year.	Opened.	Closed.	Year.	Opened.	Closed.
1874	May 5	Nov. 28	1882	Apr. 28	Nov. 28	1890	Apr. 22	Nov. 26
1875	May 17	Nov. 29	1883	May 8	Nov. 29	1891	May 8	Nov. 26
1876	May 20	Dec. 1	1884	May 10	Nov. 29	1892	May 1	Nov. 23
1877	Apr. 27	Nov. 30	1885	May 12	Nov. 29	1893	May 12	Nov. 22
1878	Apr. 7	Nov. 30	1886	May 7	Nov. 28	1894	Apr. 25	Nov. 20
1879	Apr. 27	Dec. 12	1887	May 10	Nov. 26	1895	Apr. 18	Nov. 25
1880	May 2	Nov. 16	1888	May 11	Nov. 27	1896	Apr. 25	.....
1881	May 13	Nov. 22	1889	Apr. 17	Nov. 26			

Average date of opening, May 3; average date of closing, November 27; average number of days closed, 157.

Authority: Commander William Folger, U. S. N., Eleventh light-house district.

No. 91.—OWEN SOUND, ONTARIO.

[44° 34′ latitude north. Altitude, 579.60 feet. 80° 55′ longitude west.]

Year.	Opened.	Closed.	Year.	Opened.	Closed.	Year.	Opened.	Closed.
1867	Apr. 16	Nov. 29	1877	May 1	Dec. 8	1887	Apr. 30	Dec. 8
1868	Apr. 15	Dec. 2	1878	Mar. 19	Dec. 14	1888	May 4	Dec. 4
1869	Apr. 24	Nov. 28	1879	Apr. 22	Dec. 4	1889	Apr. 14	Dec. 7
1870	Apr. 18	Dec. 5	1880	Mar. 2	Dec. 1	1890	Apr. 14	Dec. 8
1871	Mar. 22	Dec. 4	1881	Apr. 26	Dec. 31	1891	Apr. 18	Nov. 30
1872	May 9	Dec. 1	1882	Mar. 20	Dec. 13	1892	May 6	Dec. 6
1873	May 7	Dec. 11	1883	Apr. 26	Nov. 17	1893	Apr. 12	Dec. 4
1874	May 4	Nov. 31	1884	Apr. 26	Dec. 1	1894	Mar. 17	Dec. 3
1875	May 15	Dec. 2	1885	May 3	Dec. 10	1895	Apr. 20	Dec. 28
1876	May 4	Dec. 6	1886	Apr. 15	Dec. 11	1896	Apr. 20	.....

Average date of opening, April 19; average date of closing, December 6; average number of days closed, 134.

Authorities: General Report Public Works, Canada, 1867–1882; Annual Reports of the Department of Railways and Canals, Dominion of Canada, 1883–1889; Department of Public Works, Dominion of Canada, 1896.

No. 92.—PASSAGE ISLAND LIGHT-HOUSE, LAKE SUPERIOR.

[48° 14′ latitude north. Altitude, 600.69 feet. 88° 22′ longitude west.]

Year.	Opened.	Closed.	Year.	Opened.	Closed.	Year.	Opened.	Closed.
1883	May 1	Nov. 30	1888	May 14	Nov. 15	1893	May 26	Nov. 22
1884	May 8	Nov. 21	1889	Apr. 30	Nov. 12	1894	May 2	Nov. 21
1885	May 17	Nov. 15	1890	Apr. 28	Nov. 28	1895	Apr. 18	Nov. 23
1886	May 1	Nov. 11	1891	May 8	Nov. 28	1896	Apr. 23	.....
1887	May 15	Nov. 10	1892	May 1	Nov. 26			

Average date of opening, May 5; average date of closing, November 19; average number of days closed, 167.

Authority: Commander William Folger, U. S. N., Eleventh light-house district.

NOTE.—The keeper leaves before ice forms, so as to prevent loss of boat. Compared with Port Arthur, Ontario, for interpolation for twenty years' period.

No. 93.—PEARL, ILL.

[39° 28′ latitude north. Altitude, 411.11 feet. 90° 38′ longitude west.]

Year.	Opened.	Closed.	Year.	Opened.	Closed.	Year.	Opened.	Closed.
1879	.....	Dec. 18				1890	Dec. 28	Dec. 27
1880	Jan. 6	Nov. 18	1886	Feb. 23 Dec. 13	Jan. 9 Dec. 1 Dec. 15	1891	Jan. 13 Feb. 10	Jan. 13 Feb. 4
1881	Mar. 3	Open.						
1882	Open.	Dec. 7	1887	Feb. 8	Dec. 21	1892	Jan. 18	Jan. 6 Dec. 20
1883	Feb. 24	Open.	1888	Feb. 20	.....			
1884	Feb. 18	Jan. 2 Dec. 17	1889	.....	Jan. 12	1893	Feb. 25	Dec. 3
				Jan. 12 Feb. 7 Feb. 20 Mar. 1	Feb. 7 Feb. 20 Feb. 23	1894	Feb. 28	Dec. 27
1885	Jan. 11 Mar. 9 Dec. 22	Jan. 17 Dec. 11				.....	Mar. 1	.....
						1895	Dec. 25	Dec. 3
						1896	Open.	.....

Average date of opening, February 10; average date of closing, December 26; average number of days closed, 46.

Authority: Mr. John W. Davis, bridge tender for Chicago and Alton Railway.

NOTE.—Compared with Peoria, Ill., for interpolation for twenty years' period.

No. 94.—PEORIA, ILL.

[40° 41′ latitude north. Altitude, 432 feet. 89° 37′ longitude west.]

Year.	Opened.	Closed.	Year.	Opened.	Closed.	Year.	Opened.	Closed.
1834	.....	Dec. 30	1856	Mar. 22	Dec. 14	1877	Feb. 15	Open.
1835	Mar. 7	Nov. 24	1857	Feb. 18	Nov. 19	1878	Open.	Dec. 15
1836	Jan. 1	Dec. 13	1858	Feb. 19	Jan. 21	1879	Mar. 12	Dec. 12
1837	Feb. 22	Dec. 18	1859	Feb. 16	Dec. 15	1880	Jan. 2	Nov. 26
1838	Mar. 14	Nov. 5	1860	Feb. 21	Nov. 24	1881	Mar. 17	.....
1839	Feb. 18	Dec. 18	1861	Feb. 23	Dec. 21	1882	.....	Jan. 12
1840	Feb. 17	Dec. 29	1862	Mar. 12	Dec. 6	1882	Jan. 26	Dec. 8
1841	Feb. 27	Dec. 20	1863	Feb. 13	Dec. 9	1883	Mar. 7	Dec. 16
1842	Jan. 17	Nov. 13	1864	Feb. 22	Dec. 9	1884	Mar. 16	Dec. 15
1843	Mar. 19	Dec. 20	1865	Feb. 20	Dec. 12	1885	Mar. 19	Dec. 7
1844	Feb. 18	Dec. 15	1866	Mar. 3	Dec. 14	1886	Mar. 15	Dec. 1
1845	Jan. 1	Dec. 12	1867	Feb. 20	Dec. 8	1887	Feb. 21	Nov. 28
1846	Jan. 28	Dec. 18	1868	Mar. 6	.....	1888	(Mar. 19)	Dec. 15
1847	Feb. 20	Dec. 14	1869	Feb. 10	.....	1889	(Mar. 19)	Open.
1848	Jan. 1	Dec. 11	1870	Feb. 17	Dec. 20	1890	Open.	Open.
1849	Mar. 8	Dec. 16	1871	Mar. 1	Dec. 4	1891	Feb. 4	Jan. 12
1850	Jan. 26	Dec. 10	1872	Mar. 6	Nov. 25	1892	Feb. 9	Jan. 2
1851	Feb. 20	.....	1873	Mar. 14	Dec. 26			Dec. 19
1852	.....	.....	1874	Feb. 20	Dec. 21	1893	Mar. 14	Nov. 23
1853	.....	.....	1875	Mar. 15	.....	1894	Mar. 10	Dec. 24
1854	.....	.....	1876	.....	Feb. 3	1895	Mar. 15	Nov. 26
1855	.....	.....	1876	Feb. 14	Dec. 3	1896	Feb. 24	.....

Average date of opening, February 21; average date of closing, December 17; average number of days closed, 66.

Authorities: Capt. Henry Detweiller, Miss Mary E. Cleveland, river observer.

NOTE.—Compared with Seneca, Ill., for interpolation for twenty years' period.

No. 95.—PERCÉ, QUEBEC.

[48° 31′ latitude north. 64° 13′ longitude west.]

Year.	Opened.	Closed.	Year.	Opened.	Closed.	Year.	Opened.	Closed.
1867	May 11	Nov. 9	1878	Apr. 16	Dec. 2	1889	Apr. 20	Dec. 20
1868	May 11	Nov. 14	1879	Apr. 15	Nov. 27	1890	Apr. 17	Dec. 21
1869	May 10	Nov. 27	1880	Apr. 19	Dec. 1	1891	Apr. 11	Dec. 24
1870	May 6	Nov. 15	1881	Apr. 27	Nov. 17	1892	Apr. 15	Dec. 5
1871	May 4	Nov. 25	1882	Apr. 29	Dec. 7	1893	Apr. 10	Dec. 5
1872	May 9	Nov. 7	1883	Apr. 23	Nov. 23	1894	Apr. 10	Dec. 22
1873	May 9	Nov. 25	1884	Apr. 25	Dec. 1	1895	Apr. 15	.....
1874	May 7	Nov. 10	1885	May 1	Nov. 18	1896	.....	Jan. 1
1875	May 17	Dec. 5	1886	Apr. 12	Dec. 5	1896	Apr. 15	.....
1876	May 12	Dec. 7	1887	Apr. 20	Nov. 23			
1877	May 3	Nov. 23	1888	Apr. 22	Nov. 23			

Average date of opening, April 25; average date of closing, November 29; average number of days closed, 147.

Authority: Department of Public Works, Dominion of Canada, 1896.

No. 96.—PICTOU, NOVA SCOTIA.

[45° 41′ latitude north. 62° 42′ longitude west.]

Year.	Opened.	Closed.	Year.	Opened.	Closed.	Year.	Opened.	Closed.
1867	.....	.....	1879	Apr. 2	Dec. 17	1889	Mar. 14	.....
1868	.....	.....	1880	Apr. 30	Dec. 10	1890	.....	Jan. 5
1869	.....	.....	1881	Apr. 18	.....	1890	Mar. 21	Dec. 12
1870	.....	Jan. 14	1882	.....	Jan. 4	1891	Apr. 14	.....
1870	Apr. 15	Dec. 27	1882	Apr. 24	Dec. 30	1892	.....	Jan. 21
1871	Mar. 23	Dec. 15	1883	Apr. 10	Dec. 23	1892	Apr. 3	Dec. 23
1872	Apr. 25	Dec. 24	1884	Apr. 17	Dec. 24	1893	Apr. 13	Dec. 15
1873	Apr. 19	Dec. 18	1885	Apr. 21	Dec. 31	1894	Apr. 19	Dec. 24
1874	Apr. 1	Dec. 28	1886	Apr. 3	Dec. 30	1895	Apr. 19	.....
1875	May 3	Dec. 1	1887	Apr. 11	Dec. 25	1896	.....	Jan. 6
1876	Apr. 15	Dec. 27	1888	Apr. 15	.....	1896	Apr. 6	.....
1877	Apr. 7	Dec. 28	1889	.....	Jan. 14			
1878	Apr. 15	Dec. 28						

Average date of opening, April 12; average date of closing, December 25; average number of days closed, 108.

Authorities: General Report Public Works, Canada, 1867-1882; Annual Reports of the Department of Railways and Canals, Dominion of Canada, 1883-1889; Department of Public Works, Dominion of Canada, 1896.

No. 97.—PIERRE, S. DAK.

[44° 24′ latitude north. Altitude, 1,426 feet. 100° 17′ longitude west.]

Year.	Opened.	Closed.	Year.	Opened.	Closed.	Year.	Opened.	Closed.
1874	Mar. 24	Nov. 18	1882	(Apr. 7)	(Nov. 9)	1890	Apr. 6	Nov. 30
1875	Apr. 10	Nov. 16	1883	(Apr. 17)	Nov. 26	1891	Mar. 12	Nov. 24
1876	.....	Nov. 22	1884	Mar. 26	Dec. 16	1892	Mar. 27	Dec. 2
1877	Mar. 27	Dec. 16	1885	Mar. 18	Dec. 7	1893	Apr. 7	Nov. 22
1878	Mar. 18	Dec. 7	1886	Mar. 23	(Oct. 31)	1894	Apr. 6	Nov. 18
1879	Mar. 23	(Oct. 15)	1887	Apr. 18	Nov. 26	1895	Mar. 21	Nov. 22
1880	(Apr. 11)	(Nov. 4)	1888	Apr. 17	Nov. 16	1896	Mar. 27	.....
1881	(Apr. 12)	(Nov. 8)	1889	Apr. 18	Nov. 25			

Average date of opening, March 30; average date of closing, November 28; average number of days closed, 122.

Authorities: United States Weather Bureau, Mr. Frank O. Stetson, observer Weather Bureau, Pierre.

NOTE.—Dates from 1874–1889 are for Fort Sully, when station was removed to Pierre. Dates from 1890–1896 are for Pierre, 12 miles below Fort Sully. Compared with Mankato, Minn., for interpolation for twenty years' period.

No. 98.—PITTSBURG, PA.

[40° 32′ latitude north. Altitude, 699 feet. 80° 02′ longitude west.]

Year.	Opened.	Closed.	Year.	Opened.	Closed.	Year.	Opened.	Closed.
1870	Open.	Open.	1879	Open.	Open.	1888	Open.	Fltg. ice.
1871	Open.	Open.	1880	Open.	Open.	1889	Fltg. ice.	Open.
1872	Open.	Open.	1881	Open.	Open.	1890	Open.	Open.
1873	Open.	Open.	1882	Open.	Open.	1891	Open.	Open.
1874	Open.	Open.	1883	Open.	Open.	1892	Open.	Dec. 28
1875	Open.	Open.	1884	Open.	Open.	1893	Jan. 28	Open.
1876	Open.	Open.	1885	Open.	Open.	1894	Open.	Open.
1877	Open.	Open.	1886	Open.	Open.	1895	Feb. 28	Feb. 3
1878	Open.	Open.	1887	Open.	Open.	1896	Jan. 6	Jan. 4

Average date of opening, January 29; average date of closing, January 27; average number of days closed, 2.2.

Authorities: Report of United States Chief Signal Officer; Mr. T. P. Roberts.

No. 99.—POINT PLEASANT, W. VA.—KANAWHA RIVER.

[38° 53′ latitude north. Altitude, 510 feet. 82° 10′ longitude west.]

Year.	Opened.	Closed.	Year.	Opened.	Closed.	Year.	Opened.	Closed.
1871	Dec. 25	Dec. 20	1881	(Jan. 11)	(Jan. 2)	1890	Open.	Open.
1872	Feb. 11	Jan. 29	1882	(Open.)	(Open.)	1891	Open.	Open.
1873	.....	.....	1883	(Open.)	(Open.)	1892	Open.	Dec. 25
1874	.....	.....	1884	(Open.)	(Open.)	1893	Jan. 31	Open.
1875	Feb. 13	Jan. 10	1885	(Feb. 17)	(Feb. 11)	1894	Open.	Dec. 29
1876	Dec. 14	Dec. 9	1886	Jan. 24	Jan. 10	1895	Jan. 5	.....
1877	Jan. 13	Jan. 2		Feb. 10	Feb. 3		Feb. 28	Jan. 31
1878	Open.	Dec. 27	1887	Jan. 10	Jan. 9	1896	Jan. 8	Jan. 4
1879	Jan. 11	Open.			Dec. 30			
1880	Dec. 12	.....	1888	Jan. 2	Open.			
	Open.	Dec. 12	1889	Open.	Open.			

Average date of opening, January 18; average date of closing, January 6; average number of days closed, 12.

Authorities: Col. G. B. Thomas, Mr. H. Fry, Mr. Robert Kiger.

NOTE.—Compared with Charleston, W. Va., for interpolation for twenty years' period.

No. 100.—PORT ARTHUR, ONTARIO.

[48° 24′ latitude north. Altitude, 600.60 feet. 89° 28′ longitude west.]

Year.	Opened.	Closed.	Year.	Opened.	Closed.	Year.	Opened.	Closed.
1872	.....	Dec. 15	1880	Apr. 28	Dec. 30	1889	Apr. 13	Dec. 21
1873	May 9	Dec. 9	1881	Apr. 25	Dec. 31	1890	May 2	Dec. 21
1874	May 11	.....	1882	Apr. 28	Dec. 27	1891	May 2	Dec. 28
1875	May 16	Dec. 23	1883	May 8	Dec. 22	1892	May 1	Dec. 18
1876	Apr. 28	Dec. 27	1884	May 16	Dec. 14	1893	May 22	Dec. 15
1877	Mar. 17	.....	1885	May 13	Dec. 27	1894	May 3	Dec. 10
1878	.....	Jan. 10	1886	Apr. 29	Dec. 20	1895	Apr. 29	Dec. 20
1878	Apr. 23	Dec. 30	1887	May 11	Dec. 22	1896	Apr. 27	.....
1879	Apr. 25	Dec. 28	1888	May 21	Dec. 29			

Average date of opening, May 1; average date of closing, December 21; average number of days closed, 131.

Authorities: Annual Reports of the Department of Railways and Canals, Dominion of Canada, 1883–1889; Department of Public Works, Dominion of Canada, 1896.

No. 101.—PORT AUSTIN LIGHT-HOUSE, MICHIGAN.

[45° 05′ latitude north. 82° 58′ longitude west.]

Year.	Opened.	Closed.	Year.	Opened.	Closed.	Year.	Opened.	Closed.
1879	Apr. 7	Dec. 13	1885	Apr. 27	Dec. 10	1891	Apr. 9	Dec. 18
1880	Mar. 9	Dec. 7	1886	Apr. 14	Dec. 6	1892	Apr. 6	Dec. 20
1881	Apr. 28	Dec. 24	1887	Apr. 15	Dec. 19	1893	Apr. 9	Dec. 13
1882	Mar. 5	Dec. 8	1888	Apr. 15	Dec. 14	1894	Mar. 16	Dec. 20
1883	Apr. 17	Dec. 13	1889	Apr. 1	Dec. 31	1895	Apr. 9	Dec. 10
1884	Apr. 11	Dec. 14	1890	Mar. 29	Dec. 24	1896	Apr. 8	.....

Average date of opening, April 6; average date of closing, December 17; average number of days closed, 110.

Authority: Commander William Folger, U. S. N., Eleventh light-house district.

NOTE.—Compared with Port Huron, Mich., for interpolation for twenty years' period.

No. 102.—PORT DOVER, ONTARIO.

[42° 47′ latitude north. Altitude, 571.35 feet. 80° 13′ longitude west.]

Year.	Opened.	Closed.	Year.	Opened.	Closed.	Year.	Opened.	Closed.
1867	Apr. 6	Dec. 9	1877	Apr. 25	Dec. 13	1887	Apr. 8	Dec. 15
1868	Apr. 16	Dec. 2	1878	Mar. 12	Dec. 10	1888	Apr. 7	Dec. 12
1869	Apr. 24	Dec. 6	1879	Apr. 29	Dec. 27	1889	Apr. 23	Nov. 18
1870	Apr. 22	Dec. 6	1880	Apr. 2	Nov. 25	1890	Apr. 11	Nov. 6
1871	Apr. 3	Dec. 29	1881	Apr. 30	Nov. 3	1891	Apr. 14	Dec. 20
1872	Apr. 30	Dec. 2	1882	Mar. 25	Nov. 6	1892	Apr. 4	Dec. 20
1873	Apr. 28	Nov. 22	1883	Apr. 17	Dec. 1	1893	Apr. 20	Dec. 2
1874	Apr. 15	Nov. 24	1884	Apr. 17	Dec. 11	1894	Apr. 3	Dec. 15
1875	May 6	Nov. 20	1885	Apr. 28	Dec. 1	1895	Apr. 15	Dec. 12
1876	Apr. 19	Dec. 4	1886	Apr. 8	Dec. 4	1896	Apr. 3	.....

Average date of opening, April 15; average date of closing, December 4; average number of days closed, 132.

Authority: Department of Public Works, Dominion of Canada, 1896.

No. 103.—PORT HOPE, ONTARIO.

[43° 56′ latitude north. Altitude, 244.53 feet. 78° 15′ longitude west.]

Year.	Opened.	Closed.	Year.	Opened.	Closed.	Year.	Opened.	Closed.
1867	Apr. 1	Dec. 11	1878	Apr. 1	Dec. 8	1889	Apr. 2	Dec. 8
1868	Apr. 1	Dec. 7	1879	Apr. 1	Dec. 9	1890	Mar. 20	Dec. 5
1869	Apr. 1	Dec. 11	1880	Mar. 20	Dec. 15	1891	Apr. 5	Dec. 15
1870	Apr. 1	Dec. 13	1881	Apr. 1	Dec. 6	1892	Apr. 8	Dec. 12
1871	Mar. 23	Dec. 6	1882	Mar. 29	Dec. 8	1893	Apr. 3	Open.
1872	Apr. 1	Dec. 9	1883	Apr. 1	Dec. 13	1894	Open.	Open.
1873	Apr. 1	Dec. 2	1884	Apr. 1	Dec. 12	1895	Apr. 13	Jan. 23
1874	Apr. 1	Dec. 5	1885	Apr. 15	Dec. 18			Dec. 6
1875	Apr. 1	Dec. 4	1886	Apr. 2	Dec. 7	1896	Apr. 15	.....
1876	Apr. 1	Dec. 11	1887	Apr. 7	Dec. 12			
1877	Apr. 1	Dec. 11	1888	Apr. 13	Dec. 10			

Average date of opening, April 3; average date of closing, December 15; average number of days closed, 109.

Authorities: General Report Public Works, Canada, 1867-1882; Annual Reports of the Department of Railways and Canals, Dominion of Canada, 1883-1889; Department of Public Works, Dominion of Canada, 1896.

No. 104.—PORT HURON, MICH.

[43° 00′ latitude north. Altitude, 579.6 feet. 82° 26′ longitude west.]

Year.	Opened.	Closed.	Year.	Opened.	Closed.	Year.	Opened.	Closed.
1871	Mar. 16	Nov. 30	1880	Mar. 22	Dec. 10	1888	Mar. 10	Dec. 11
1872	Apr. 12	Nov. 23	1881	Apr. 27	Nov. 21	1889	Apr. 1	Dec. 11
1873	Apr. 14	Nov. 19	1882	Mar. 7	Dec. 10	1890	Mar. 30	Dec. 25
1874	Mar. 23	Dec. 20	1883	Apr. 18	.....	1891	Apr. 19	Dec. 22
1875	Apr. 10	Dec. 11	1884	.....	Jan. 5	1892	Apr. 2	Dec. 15
1876	Apr. 6	Dec. 16	1884	Apr. 8	Nov. 13	1893	Apr. 1	Dec. 13
1877	Apr. 23	Dec. 9	1885	Apr. 23	Dec. 16	1894	Mar. 11	Dec. 19*b*
1878	Mar. 24	Dec. 15	1886	Mar. 28	Dec. 12	1895	Apr. 7*a*	Dec. 28*b*
1879	Apr. 3	Dec. 14	1887	Apr. 12	Dec. 10	1896	Apr. 8*a*	.....

a First boat. *b* Last boat.

Average date of opening, April 4; average date of closing, December 11; average number of days closed, 114.

Authorities: United States Weather Bureau, 1896; Mr. W. M. Edmondson, observer Weather Bureau, Port Huron, 1896.

No. 105.—FORT STANLEY, ONTARIO.

[42° 40′ latitude north. Altitude, 571.35 feet. 81° 13′ longitude west.]

Year.	Opened.	Closed.	Year.	Opened.	Closed.	Year.	Opened.	Closed.
1867	Apr. 1	Dec. 10	1879	Apr. 5	Dec. 20	1890	Mar. 27	Dec. 24
1868	Apr. 1	Dec. 10	1880	Mar. 20	Dec. 15	1891	Mar. 17	.....
1869	Apr. 1	Dec. 5	1881	Apr. 10	Dec. 10	1892	.....	Jan. 12
1870	Apr. 10	Dec. 10	1882	Apr. 1	Dec. 10	1892	Feb. 26	Dec. 25
1871	Mar. 20	Dec. 20	1883	Apr. 14	Dec. 28	1893	Mar. 25	.....
1872	Apr. 10	Dec. 5	1884	Apr. 1	Dec. 19	1894	.....	Jan. 10
1873	Apr. 1	Dec. 5	1885	Apr. 21	Dec. 22	1894	Mar. 14	Dec. 27
1874	Mar. 20	Dec. 5	1886	Mar. 21	Dec. 6	1895	Apr. 4	Dec. 10
1875	Apr. 10	Dec. 20	1887	Apr. 4	Dec. 23	1896	Mar. 29	.....
1876	Apr. 1	Dec. 5	1888	Mar. 31	.....			
1877	Apr. 10	Dec. 10	1889	.....	Feb. 9			
1878	Apr. 1	Dec. 10	1889	Mar. 15	Dec. 28			

Average date of opening, March 30; average date of closing, December 18; average number of days closed, 102.

Authorities: General report Public Works, Canada, 1867-1882; Annual Report of the Department of Railways and Canals, Dominion of Canada, 1883-1889; Department of Public Works, Dominion of Canada, 1896.

No. 106.—PORTAGE RIVER LIGHT-HOUSE, MICHIGAN.

[46° 59′ latitude north. Altitude, 600.69 feet. 88° 24′ longitude west.]

Year.	Opened.	Closed.	Year.	Opened.	Closed.	Year.	Opened.	Closed.
1874.....	May 6	Nov. 30	1882.....	Apr. 18	Dec. 4	1890.....	Apr. 21	Dec. 6
1875.....	May 11	Nov. 27	1883.....	May 1	Nov. 30	1891.....	Apr. 26	Dec. 5
1876.....	May 6	Dec. 7	1884.....	May 1	Dec. 4	1892.....	Apr. 21	Dec. 9
1877.....	Apr. 29	Dec. 11	1885.....	May 2	Dec. 5	1893.....	May 7	Dec. 5
1878.....	Mar. 16	Dec. 2	1886.....	Apr. 28	Dec. 15	1894.....	Apr. 20	Dec. 4
1879.....	Apr. 25	Nov. 30	1887.....	May 2	Nov. 30	1895.....	Apr. 19	Dec. 5
1880.....	Apr. 20	Nov. 22	1888.....	May 7	Dec. 3	1896.....	Apr. 20	.....
1881.....	May 1	Nov. 30	1889.....	Apr. 15	Dec. 1			

Average date of opening, April 25; average date of closing, December 3; average number of days closed, 143.

Authority: Commander William Folger, U. S. N., Eleventh light-house district.

No. 107.—PORTE DES MORTS LIGHT-HOUSE, WISCONSIN.

[45° 17′ latitude north. Altitude, 579.60 feet. 86° 55′ longitude west.]

Year.	Opened.	Closed.	Year.	Opened.	Closed.	Year.	Opened.	Closed.
1887.....	Apr. 20	Dec. 15	1892.....	Apr. 10	Dec. 18	1895.....	Apr. 15	.....
1888.....	Apr. 22	Dec. 31	1893.....	Apr. 18	Dec. 13	1896.....	.....	Jan. 9
1889.....	Apr. 2	Dec. 15	1894.....	Mar. 28	.....	1896.....	Mar. 31	.....
1890.....	Apr. 8	Dec. 9	1895.....	.....	Feb. 4			
1891.....	Apr. 20	Dec. 16						

Average date of opening, April 10; average date of closing, December 24; average number of days closed, 107.

Authority: Commander J. H. Dayton, U. S. N., Ninth light-house district.

NOTE.—Compared with Escanaba, Mich., for interpolation for twenty years' period.

No. 108.—POVERTY ISLAND LIGHT-HOUSE, MICHIGAN.

[45° 31′ latitude north. Altitude, 579.60 feet. 86° 40′ longitude west.]

Year.	Opened.	Closed.	Year.	Opened.	Closed.	Year.	Opened.	Closed.
1887.....	Apr. 25	Dec. 6	1891.....	Apr. 14	Dec. 7	1895.....	Apr. 14	Dec. 10
1888.....	Apr. 24	Dec. 6	1892.....	Apr. 12	Dec. 9	1896.....	Apr. 14	.....
1889.....	Apr. 1	Dec. 8	1893.....	Apr. 22	Dec. 7			
1890.....	Apr. 5	Dec. 7	1894.....	Apr. 7	Dec. 10			

Average date of opening, April 13; average date of closing, December 8; average number of days closed, 126.

Authority: Commander J. H. Dayton, U. S. N., Ninth light house district

NOTE.—Compared with Alpena, Mich., for interpolation for twenty years' period.

No. 109.—QUEBEC, PROVINCE OF QUEBEC.—ST. CHARLES RIVER.

[46° 39′ latitude north. Altitude, 6.11 feet. 71° 12′ longitude west.]

Year.	Opened.	Closed.	Year.	Opened.	Closed.	Year.	Opened.	Closed.
1814	Apr. 28	Dec. 7	1842	Apr. 26	Dec. 2	1870	Apr. 16	Dec. 2*b*
1815	Apr. 28	Dec. 5	1843	May 5*a*	Dec. 1	1871	Apr. 17*c*	Dec. 1
1816	Apr. 3	Nov. 29	1844	Apr. 23	Nov. 29	1872	Apr. 27	Nov. 26*b*
1817	May 6*a*	Dec. 5	1845	Apr. 23	Dec. 2	1873	Apr. 28	Nov. 22*b*
1818	Apr. 27	Dec. 1	1846	Apr. 14	Dec. 9	1874	Apr. 28	Nov. 25*b*
1819	Apr. 30	Dec. 7	1847	May 11	Dec. 3	1875	Apr. 26	Nov. 23*b*
1820	Apr. 24	Dec. 1	1848	Apr. 18	Dec. 5	1876	May 6*a*	Nov. 24*b*
1821	May 3	.....	1849	Apr. 24	Dec. 7	1877	Apr. 25	Nov. 25*b*
1822	Apr. 29	Dec. 8	1850	Apr. 26	Dec. 10	1878	Apr. 20	Nov. 25
1823	Apr. 25	.....	1851	Apr. 22*a*	Dec. 5	1879	Apr. 29	Nov. 28
1824	Apr. 20	Dec. 11	1852	Apr. 30*a*	Dec. 19	1880	Apr. 8	Nov. 27
1825	Apr. 19	.....	1853	Apr. 26	Dec. 3	1881	Apr. 1	Nov. 28
1826	Apr. 22	Dec. 21	1854	May 5*a*	Dec. 5	1882	Apr. 22	Dec. 2
1827	Apr. 14	.....	1855	May 8*a*	Nov. 27	1883	Apr. 23	Dec. 1
1828	Apr. 12	.....	1856	Apr. 22	Dec. 2	1884	Apr. 20	Dec. 14
1829	Apr. 18	.....	1857	Apr. 28*c*	Dec. 4	1885	Apr. 29	Dec. 7
1830	Apr. 17*a*	Dec. 4*b*	1858	Apr. 16	Dec. 3	1886	Apr. 11	Dec. 4
1831	Apr. 21	Nov. 30*b*	1859	Apr. 26	Nov. 29	1887	Apr. 30	Nov. 28
1832	Apr. 29	Nov. 30*b*	1860	Apr. 20	Dec. 8	1888	Apr. 19	Nov. 23
1833	Apr. 19	Nov. 25*b*	1861	Apr. 26	Dec. 17	1889	Apr. 13	Dec. 4
1834	Apr. 18	Dec. 9	1862	Apr. 11	Dec. 5	1890	Apr. 23	Dec. 1
1835	May 4*a*	Dec. 1	1863	May 1*a*	Dec. 4	1891	Apr. 20	Dec. 17
1836	May 10*a*	Dec. 1	1864	Apr. 19	Dec. 13	1892	Apr. 19	Dec. 20
1837	May 2*a*	Dec. 12	1865	Apr. 18	Dec. 9	1893	Apr. 30	Dec. 4
1838	May 1*a*	Nov. 26	1866	Apr. 27	Dec. 15	1894	Apr. 19	Nov. 27
1839	Apr. 23	Dec. 19	1867	Apr. 17	Nov. 29*b*	1895	Apr. 17	Dec. 2
1840	Apr. 21	Dec. 2	1868	Apr. 23*c*	Dec. 1	1896	Apr. 27	.....
1841	May 4*a*	Dec. 14	1869	Apr. 27*c*	Nov. 30			

a First steamer. *b* Last steamer. *c* Ships from sea.

Average date of opening, April 21; average date of closing, December 4; average number of days closed, 138.

Authorities: General Report Public Works, Canada, 1867-1882; Annual Reports, Department of Railways and Canals, Dominion of Canada, 1883-1887; Mr. Simons, engineer to the Quebec harbor commissioners, 1876; Department of Public Works, Dominion of Canada, 1896; Mr. Jas. Wood, secretary and treasurer Quebec harbor commissioners.

No. 110.—QUINCY, ILL.

[39° 55′ latitude north. Altitude, 458 feet. 91° 25′ longitude west.]

Year.	Opened.	Closed.	Year.	Opened.	Closed.	Year.	Opened.	Closed.
1876	.....	Nov. 30	1885	Mar. 13	Dec. 5	1893	Mar. 2	.....
1877	Feb. 19	Dec. 29	1886	Mar. 8	Nov. 24	1894	.....	Jan. 25
1878	Jan. 14	Dec. 13	1887	Feb. 27	Dec. 4	1894	Mar. 3	Dec. 29
1879	Mar. 7	Dec. 11	1888	Mar. 14	Dec. 11	1895	Feb. 28	Dec. 9
1880	Jan. 16	Nov. 16	1889	Mar. 10	Nov. 25	1896	Feb. 21	.....
1881	Mar. 21	Dec. 27	1890	Mar. 19	Dec. 6			
1882	Jan. 29	Dec. 9	1891	Mar. 19	.....			
1883	Mar. 5	Dec. 8	1892	.....	Jan. 7			
1884	Mar. 23	Dec. 12	1892	Feb. 5	Dec. 20			

Average date of opening, February 27; average date of closing, December 13; average number of days closed, 76.

Authorities: Mr. J. M. Hyman, superintendent railroad bridge; Mr. E. J. Blake, chief engineer Chicago, Burlington and Quincy Railroad Company.

No. 111.—ROCHESTER, N. Y.

[43° 08′ latitude north. Altitude, 508 feet. 77° 42′ longitude west.]

Year.	Opened.	Closed.	Year.	Opened.	Closed.	Year.	Opened.	Closed.
1874	Mar 23	Dec. 17	1882	Mar. 30	Dec. 8	1890	(Mar. 26)	.....
1875	Apr. 19	Dec. 3	1883	Apr. 9	Dec. 12	1891	.....	(Jan. 11)
1876	Apr. 8	Dec. 1	1884	Apr. 4	Dec. 21	1891	(Apr. 5)	(Dec. 22)
1877	Apr. 5	Dec. 21	1885	Apr. 24	Dec. 15	1892	(Apr. 6)	(Dec. 15)
1878	Apr. 4	Dec. 1	1886	Apr. 4	(Dec. 13)	1893	(Apr. 6)	(Dec. 11)
1879	Apr. 7	Dec. 2	1887	(Apr. 10)	(Dec. 10)	1894	(Mar. 31)	(Dec. 12)
1880	Mar. 24	Dec. 19	1888	(Apr. 15)	(Dec. 5)	1895	(Apr. 20)	(Dec. 13)
1881	Mar. 26	Dec. 5	1889	(Apr. 5)	(Dec. 12)	1896	(Apr. 15)	.....

Average date of opening, April 5; average date of closing, December 9; average number of days closed, 117.

Authority: United States Weather Bureau.

NOTE.—Compared with Oswego, N. Y., for interpolation for twenty years' period.

No. 112.—ROCK ISLAND, ILL.

[41° 29′ latitude north. Altitude, 541 feet. 90° 37′ longitude west.]

Year.	Opened.	Closed.	Year.	Opened.	Closed.	Year.	Opened.	Closed.
1851	.....	Dec. 16	1868	Mar. 12	Dec. 28	1884	Mar. 27	Dec. 15
1852	Mar. 4	Dec. 17	1869	Feb. 14	.....	1885	Mar. 31	Dec. 6
1853	Mar. 3	Dec. 25	1870	.....	Jan. 19	1886	Mar. 19	Nov. 30
1854	Mar. 1	Dec. 31	1870	Mar. 27	Dec. 20	1887	Mar. 17	Dec. 20
1855	Mar. 10	Dec. 22	1871	Feb. 28	Nov. 28	1888	Mar. 24	.....
1856	Mar. 19	Dec. 2	1872	Mar. 27	Nov. 30	1889	.....	Jan. 9
1857	Mar. 22	Open.	1873	Mar. 15	Dec. 4	1889	Mar. 12	.....
1858	Open.	Open.	1874	Mar. 2	Dec. 29	1890	.....	Jan. 20
1859	Open.	Dec. 19	1875	Apr. 6	Dec. 16	1890	Mar. 17	.....
1860	Mar. 5	Dec. 20	1876	Jan. 1	Nov. 30	1891	.....	Jan. 9
1861	Mar. 5	Dec. 21	1877	Mar. 28	Open.	1891	Mar. 17	.....
1862	Apr. 1	Open.	1878	Open.	Dec. 16	1892	.....	Jan. 2
1863	Open.	Dec. 12	1879	Mar. 19	Dec. 11	1892	Mar. 15	Dec. 22
1864	Mar. 5	Dec. 7	1880	Jan. 13	Nov. 20	1893	Mar. 31	Dec. 30
1865	Mar. 16	Dec. 11	1881	Apr. 20	Open.	1894	Mar. 6	Dec. 27
1866	Apr. 4	Dec. 23	1882	Open.	Dec. 6	1895	Mar. 20	Dec. 31
1867	Apr. 6	Dec. 7	1883	Mar. 21	Dec. 16	1896	Feb. 25	.....

Average date of opening, March 14; average date of closing, December 28; average number of days closed, 76.

Authorities: Mr. C. H. Stoddard; Mr. T. J. Robinson, president Rock Island National Bank.

No. 113.—ROUSE POINT, N. Y.

[44° 59′ latitude north. Altitude, 95.03 feet. 73° 22′ longitude west.]

Year.	Opened.	Closed.	Year.	Opened.	Closed.	Year.	Opened.	Closed.
1875	.....	Nov. 25	1883	May 3*a*	Nov. 30	1890	Apr. 7	Dec. 4
1876	.....	Dec. 1	1884	Apr. 19	Dec. 1	1891	Apr. 13	Dec. 1
1877	Apr. 17	Dec. 22	1885	Apr. 18*a*	Dec. 3	1892	Apr. 12	Nov. 29
1878	.....	Dec. 17	1886	Apr. 19	Dec. 11	1893	Apr. 25	Dec. 5
1879	May 2*a*	Dec. 3	1887	May 1	Dec. 2	1894	Mar. 28*a*	Nov. 28
1880	Apr. 10	Nov. 22	1888	May 7*a*	Dec. 19	1895	Apr. 18*a*	Dec. 3
1881	Apr. 4*a*	Dec. 10	1889	Apr. 18	Dec. 13	1896	Apr. 20	.....
1882	Mar. 28*a*	Nov. 28						

a First boat passed bridge.

Average date of opening, April 17; average date of closing, December 5; average number of days closed, 133.

Authorities: Mr. F. W. Baldwin, general manager Vermont Central Railway; Mr. E. H. Starks, bridge tender, Vermont Central Railway at Richelieu River.

No. 114.—SAGINAW RIVER LIGHT RANGES, MICHIGAN.

[43° 38′ latitude north. 83° 50′ longitude west.]

Year.	Opened.	Closed.	Year.	Opened.	Closed.	Year.	Opened.	Closed.
1874	Mar. 24	Dec. 7	1882	Mar. 6	Dec. 7	1890	Apr. 1	Dec. 4
1875	Apr. 20	Dec. 2	1883	Apr. 16	Dec. 16	1891	Apr. 7	Dec. 14
1876	Apr. 15	Dec. 2	1884	Apr. 12	Dec. 12	1892	Apr. 6	Dec. 12
1877	Apr. 18	Dec. 31	1885	Apr. 24	Dec. 9	1893	Apr. 14	Dec. 2
1878	Mar. 7	Dec. 14	1886	Apr. 17	Dec. 4	1894	Apr. 1	Dec. 5
1879	Apr. 6	Dec. 17	1887	Apr. 18	Dec. 4	1895	Apr. 20	Dec. 3
1880	Mar. 2	Nov. 23	1888	Apr. 16	Dec. 17	1896	Apr. 8	.....
1881	Apr. 25	Dec. 31	1889	Mar. 29	Dec. 30			

Average date of opening, April 7; average date of closing, December 10; average number of days closed, 118.

Authority: Commander William Folger, U. S. N., Eleventh light-house district.

No. 115.—ST. PAUL, MINN.

[44° 58′ latitude north. Altitude, 683 feet. 93° 03′ longitude west.]

Year.	Opened.	Closed.	Year.	Opened.	Closed.	Year.	Opened.	Closed.
1855	Apr. 17	Nov. 19	1869	Apr. 19	Nov. 20	1883	Apr. 20	Nov. 6
1856	Apr. 18	Nov. 10	1870	Apr. 10	Nov. 6	1884	Apr. 16	Nov. 12
1857	May 1	Nov. 16	1871	Apr. 10	Nov. 20	1885	Apr. 21	Nov. 16
1858	Mar. 25	Nov. 16	1872	Apr. 23	Nov. 15	1886	Apr. 17	Nov. 10
1859	Apr. 20	Nov. 29	1873	Apr. 17	Nov. 12	1887	Apr. 20	Nov. 26
1860	Mar. 28	Nov. 23	1874	Apr. 23	Nov. 16	1888	Apr. 20	Dec. 22
1861	Apr. 8	Nov. 25	1875	Apr. 25	Nov. 17	1889	Apr. 6	Nov. 25
1862	Apr. 18	Nov. 15	1876	Apr. 22	Nov. 19	1890	Apr. 24	Dec. 2
1863	Apr. 6	Nov. 24	1877	Apr. 17	Nov. 27	1891	Mar. 30	Nov. 29
1864	Apr. 14	Nov. 11	1878	Apr. 20	Dec. 1	1892	Apr. 21	Nov. 21
1865	Apr. 15	Dec. 1	1879	Apr. 21	Oct. 25	1893	Apr. 30	Dec. 12
1866	Apr. 19	Nov. 23	1880	Apr. 14	Nov. 16	1894	Mar. 7	Nov. 29
1867	Apr. 21	Nov. 29	1881	Apr. 15	Nov. 18	1895	Mar. 21	Nov. 28
1868	Apr. 4	Nov. 1	1882	Apr. 10	Nov. 19	1896	Mar. 9	.....

Average date of opening, April 13; average date of closing, November 21; average number of days closed, 142.

Authorities: United States Weather Bureau, 1871–1895; Mr. P. F. Lyons, St. Paul Weather Bureau. 1896.

No. 116.—SAND BEACH LIGHT-HOUSE, MICHIGAN.

[43° 51′ latitude north. Altitude, 579.60 feet. 82° 37′ longitude west.]

Year.	Opened.	Closed.	Year.	Opened.	Closed.	Year.	Opened.	Closed.
1879	Apr. 4	Dec. 17	1885	Apr. 25	Dec. 10	1891	Apr. 1	Dec. 30
1880	Mar. 22	Dec. 9	1886	Apr. 1	Dec. 16	1892	Apr. 6	Dec. 31
1881	Apr. 26	Dec. 31	1887	Apr. 12	Dec. 22	1893	Apr. 8	Dec. 19
1882	Mar. 8	Dec. 9	1888	Apr. 5	Dec. 21	1894	Mar. 10	Dec. 27
1883	Apr. 18	Dec. 14	1889	Mar. 31	Dec. 31	1895	Apr. 7	Dec. 19
1884	Apr. 9	Dec. 18	1890	Mar. 14	Dec. 25	1896	Apr. 8	.....

Average date of opening, April 3; average date of closing, December 20; average number of days closed, 104.

Authority: Commander William Folger, U. S. N., Eleventh light-house district.

NOTE.—Compared with Port Huron, Mich., for interpolation for twenty years' period.

No. 117.—SANDUSKY BAY, OHIO.—CEDAR POINT LIGHT-HOUSE.

[41° 25′ latitude north. Altitude, 571.35 feet. 82° 40′ longitude west.]

Year.	Opened.	Closed.	Year.	Opened.	Closed.	Year.	Opened.	Closed.
1871	Apr. 1	Dec. 7	1880	Apr. 1	Dec. 7	1889	Mar. 22	Dec. 24
1872	Apr. 1	Nov. 30	1881	Mar. 1	Dec. 31	1890	Mar. 18	Dec. 27
1873	Mar. 18	Nov. 29	1882	Mar. 1	Dec. 16	1891	Mar. 12	Dec. 21
1874	Mar. 7	Dec. 13	1883	Apr. 6	Dec. 23	1892	Mar. 14	Dec. 25
1875	Apr. 5	Dec. 16	1884	Apr. 1	Dec. 19	1893	Mar. 23	Dec. 19
1876	Mar. 10	Dec. 9	1885	Apr. 8	Dec. 13	1894	Mar. 15	Dec. 31
1877	Mar. 5	Dec. 31	1886	Mar. 28	Dec. 9	1895	Mar. 30	Dec. 16
1878	Mar. 10	Dec. 23	1887	Mar. 24	Dec. 24	1896	Mar. 30	.....
1879	Apr. 1	Dec. 26	1888	Mar. 20	Dec. 31			

Average date of opening, March 22; average date of closing, December 19; average number of days closed, 93.

Authorities: Mr. James A. Ryan, The Register, Sandusky; Lieut. Col. Jared A. Smith, United States Army engineer, Tenth light-house district.

No. 118.—SAND POINT LIGHT-HOUSE, L'ANSE, MICH.

[46° 47′ latitude north. Altitude, 600.69 feet. 88° 28′ longitude west.]

Year.	Opened.	Closed.	Year.	Opened.	Closed.	Year.	Opened.	Closed.
1879	Apr. 25	Nov. 30	1885	May 1	Dec. 8	1891	Apr. 27	Dec. 6
1880	Apr. 26	Nov. 25	1886	Apr. 27	Dec. 6	1892	Apr. 21	Dec. 10
1881	May 1	Nov. 28	1887	May 2	Dec. 1	1893	May 8	Dec. 4
1882	Apr. 25	Dec. 3	1888	May 6	Nov. 30	1894	Apr. 21	Nov. 30
1883	May 1	Nov. 30	1889	Apr. 16	Nov. 30	1895	Apr. 23	Dec. 8
1884	May 1	Dec. 6	1890	Apr. 21	Nov. 30	1896	Apr. 19	.....

Average date of opening, April 27; average date of closing, December 2; average number of days closed, 146.

Authority: Commander William Folger, U. S. N., Eleventh light-house district.

NOTE.—Compared with Portage River light-house, Michigan, for interpolation for twenty years' period.

No. 119.—SARNIA, ONTARIO.

[42° 59′ latitude north. Altitude, 579.60 feet. 82° 24′ longitude west.]

Year.	Opened.	Closed.	Year.	Opened.	Closed.	Year.	Opened.	Closed.
1867	Mar. 30	Dec. 30	1878	Mar. 20	Dec. 24	1888	Apr. 9	Dec. 17
1868	Mar. 16	Dec. 12	1879	Mar. 20	Dec. 26	1889	Apr. 15	.....
1869	Apr. 1	.....	1880	Mar. 6	Dec. 18	1890	.....	Jan. 4
1870	.....	Jan. 6	1881	Apr. 4	.....	1890	Mar. 25	Dec. 11
1870	Mar. 29	Dec. 23	1882	.....	Jan. 10	1891	Apr. 25	Dec. 3
1871	Mar. 6	Dec. 21	1882	Mar. 11	.....	1892	Apr. 5	Dec. 18
1872	Mar. 18	Dec. 19	1883	.....	Jan. 8	1893	Apr. 3	Dec. 11
1873	Mar. 18	.....	1883	Apr. 5	.....	1894	Mar. 16	Dec. 28
1874	.....	Jan. 12	1884	.....	Jan. 3	1895	Apr. 6	Dec. 12
1874	Mar. 17	Dec. 24	1884	Mar. 31	Dec. 25	1896	Apr. 3	.....
1875	Mar. 29	Dec. 18	1885	Apr. 14	.....			
1876	Mar. 20	Dec. 18	1886	.....	Jan. 8			
1877	Apr. 7	.....	1886	Mar. 22	Dec. 15			
1878	.....	Jan. 12	1887	Apr. 4	Dec. 4			

Average date of opening, March 28; average date of closing, December 24; average number of days closed, 94.

Authorities: General Report Public Works, Canada, 1867–1882; Annual Reports of the Department of Railways and Canals, Dominion of Canada, 1883–1889; Department of Public Works, Dominion of Canada, 1896.

No. 120.—SAULT STE. MARIE, ONTARIO.

[46° 30′ latitude north. Altitude, 581.41 feet. 84° 22′ longitude west.]

Year.	Opened.	Closed.	Year.	Opened.	Closed.	Year.	Opened.	Closed.
1867	May 4	Dec. 3	1877	May 2	Nov. 30	1887	May 1	Dec. 1
1868	May 2	Dec. 3	1878	May 8	Dec. 3	1888	May 8	Dec. 4
1869	May 4	Nov. 29	1879	May 2	Dec. 3	1889	Apr. 17	Dec. 4
1870	Apr. 29	Dec. 1	1880	Apr. 28	Nov. 15	1890	Apr. 20	Dec. 4
1871	May 8	Nov. 29	1881	.....	Dec. 5	1891	Apr. 28	Dec. 4
1872	May 11	Nov. 26	1882	Apr. 21	Dec. 3	1892	Apr. 18	Dec. 6
1873	May 5	Nov. 18	1883	May 2	Dec. 9	1893	Apr. 29	Dec. 1
1874	May 12	Dec. 2	1884	Apr. 25	Dec. 10	1894	Apr. 17	Dec. 6
1875	May 12	Dec. 2	1885	May 6	Nov. 20	1895	Apr. 23	Dec. 11
1876	May 8	Nov. 26	1886	Apr. 26	Dec. 4	1896	Apr. 18	.....

Average date of opening, April 30; average date of closing, December 2; average number of days closed, 149.

Authority: Department of Public Works, Dominion of Canada, 1896.

No. 121.—SENECA, ILL.

[41° 14′ latitude north. 88° 37′ longitude west.]

Year.	Opened.	Closed.	Year.	Opened.	Closed.	Year.	Opened.	Closed.
1849	Jan. 27	Dec. 10	1865	Feb. 6	Dec. 14	1882	Open.	Dec. 6
1850	Feb. 14	Dec. 6	1866	Feb. 24	Dec. 25	1883	Mar. 1	Dec. 25
1851	Feb. 20	Dec. 13	1867	Feb. 14	Nov. 30	1884	Mar. 18	Dec. 18
1852	.....	Open.	1868	Feb. 20	Dec. 9	1885	Mar. 2	.....
1853	Open.	Dec. 30	1869	Jan. 5	Mar. 1	1886	.....	Jan. 10
1854	Mar. 1	.....	1869	Mar. 15	.....	1886	Feb. 13	Dec. 20
1855	.....	Jan. 22	1870	.....	Jan. 18	1887	Feb. 8	Dec. 29
1855	Mar. 9	Dec. 24	1870	Feb. 10	Dec. 19	1888	Mar. 15	.....
1856	Feb. 29	Dec. 4	1871	Feb. 15	Dec. 6	1889	.....	Jan. 12
1857	Feb. 6	Nov. 20	1872	Feb. 25	Dec. 9	1889	Mar. 15	Open.
1857	Dec. 3	.....	1873	.....	.....	1890	Open.	(Open.)
1858	.....	Feb. 12	1874	.....	Jan. 16	1891	(Feb. 3)	.....
1858	Feb. 16	Open.	1874	Feb. 29	.....	1892	.....	Jan. 15
1859	Open.	Dec. 8	1875	Mar. 26	Open.	1892	Feb. 1	Dec. 26
1860	Feb. 23	Nov. 24	1876	Open.	Dec. 6	1893	Mar. 5	Dec. 4
1861	.....	Dec. 2	1877	Feb. 5	Open.	1894	Feb. 6	.....
1862	Mar. 10	.....	1878	Open.	Dec. 20	1895	.....	Jan. 4
1863	.....	Jan. 17	1879	Mar. 7	Dec. 19	1895	Feb. 26	.....
1863	Feb. 15	Dec. 30	1880	Jan. 5	Nov. 18	1896	.....	Jan. 4
1864	Feb. 1	Dec. 10	1881	Apr. 2	Open.	1896	Feb. 25	.....

Average date of opening, February 21; average date of closing, January 2; average number of days closed, 50.

Authority: Mr. D. L. Carpenter.

NOTE.—Compared with Peoria, Ill., for interpolation for twenty years' period.

No. 122.—SHEDIAC, NEW BRUNSWICK.

[46° 15′ latitude north. 64° 32′ longitude west.]

Year.	Opened.	Closed.	Year.	Opened.	Closed.	Year.	Opened.	Closed.
1867	.....	.....	1877	Apr. 25	Dec. 15	1887	May 7	Dec. 23
1868	.....	.....	1878	Apr. 29	Nov. 17	1888	May 8	Dec. 12
1869	.....	.....	1879	May 1	Dec. 13	1889	Apr. 18	Dec. 13
1870	.....	.....	1880	May 26	Nov. 22	1890	Apr. 21	Dec. 2
1871	.....	.....	1881	May 19	Dec. 2	1891	Apr. 23	Dec. 15
1872	.....	.....	1882	May 9	Dec. 7	1892	Apr. 7	Dec. 21
1873	.....	.....	1883	Apr. 23	Dec. 1	1893	Apr. 14	Dec. 11
1874	.....	.....	1884	May 12	.....	1894	Apr. 20	Dec. 8
1875	.....	.....	1885	.....	Dec. 7	1895	Apr. 22	Dec. 10
1876	May 16	Dec. 9	1886	Apr. 27	Dec. 10	1896	Apr. 25	.....

Average date of opening, April 29; average date of closing, December 8; average number of days closed, 142.

Authorities: General Report Public Works, Canada, 1867–1882; Annual Report of the Department of Railways and Canals, Dominion of Canada, 1883–1889; Department of Public Works, Dominion of Canada, 1896.

No. 123.—SIOUX CITY, IOWA.

[42° 29′ latitude north. Altitude, 1,066 feet. 96° 24′ longitude west.]

Year.	Opened.	Closed.	Year.	Opened.	Closed.	Year.	Opened.	Closed.
1870	.....	Dec. 20	1881	Mar. 26	Dec. 30	1890	Mar. 20	.....
1871	.....	Nov. 23	1882	Mar. 1	Nov. 21	1891	.....	Jan. 4
1872	.....	Nov. 19	1883	Mar. 13	Nov. 30	1891	Apr. 10	Dec. 15
1873	.....	Dec. 4	1884	Mar. 22	Nov. 22	1892	Mar. 15	Dec. 19
1874	.....	Nov. 25	1885	Mar. 13	Dec. 5	1893	Mar. 22	Nov. 24
1875	.....	Nov. 28	1886	Mar. 23	Nov. 19	1894	Mar. 4	Dec. 28
1876	.....	Dec. 1	1887	Mar. 11	Nov. 27	1895	Mar. 20	Dec. 1
1877	.....	Nov. 29	1888	Apr. 2	.....	1896	(Feb. 26)	Mar. 8
1878	.....	Dec. 18	1889	.....	Jan. 20		(Mar. 21)	
1879	Mar. 7	(Feb. 28 (Dec. 8	1889	Mar. 5	Nov. 29			
1880	(Feb. 24 (Mar. 20	Nov. 18	1889	Dec. 1	.....			
			1890	.....	Jan. 1			

Average date of opening, March 17; average date of closing, December 17; average number of days closed, 90.

Authorities: United States Weather Bureau, 1887–1894; Report of the United States Missouri River Commission, 1887; Report of the United States Missouri River Commission, "Stages of the Missouri River," 1894; Mr. A. F. Nash, postmaster, 1896.

No. 124.—SOUTH FOX ISLAND LIGHT-HOUSE, MICHIGAN.

[45° 22′ latitude north. Altitude, 579.60 feet. 85° 50′ longitude west.]

Year.	Opened.	Closed.	Year.	Opened.	Closed.	Year.	Opened.	Closed.
1887	Apr. 18	Dec. 12	1891	Apr. 6	Dec. 7	1895	Apr. 11	Dec. 19
1888	Apr. 24	Dec. 11	1892	Apr. 5	Dec. 9	1896	Apr. 1	.....
1889	Apr. 1	Dec. 16	1893	Apr. 12	Dec. 8			
1890	Mar. 28	Dec. 12	1894	Apr. 5	Dec. 13			

Average date of opening, April 7; average date of closing, December 12; average number of days closed, 116.

Authority: Commander J. H. Dayton, U. S. N., Ninth light-house district.

NOTE.—Compared with Alpena, Mich., for interpolation for twenty years' period.

No. 125.—ST. CHARLES, MO.

[38° 46′ latitude north. Altitude, 416 feet. 90° 45′ longitude west.]

Year.	Opened.	Closed.	Year.	Opened.	Closed.	Year.	Opened.	Closed.
1878	.....	Dec. 27	1885	.....	Dec. 11	1892	Jan. 28	Jan. 19
1879	Jan. 26	.....	1885	Dec. 25	.....	1893	Feb. 16	Jan. 6
1880	.....	Dec. 29	1886	.....	Jan. 19	1894	Open.	Open.
1881	Feb. 12	(Open.)	1886	Feb. 12	Dec. 31	1895	Jan. 20	Jan. 13
1882	(Open.)	.....	1887	Jan. 22	Dec. 30	1895	Feb. 25	Feb. 3
1883	.....	Jan. 12	1888	Jan. 8	Open.	1896	Open.	.....
1883	Feb. 15	.....	1889	Open.	Open.			
1884	.....	Jan. 5	1890	Open.	Open.			
1884	Jan. 31	Open.	1891	Open.	Open.			

Average date of opening, January 29; average date of closing, January 10; average number of days closed, 19.

Authorities: Report of United States Missouri River Commission, 1887; Missouri River Commission, "Stages of the Missouri River," 1894; United States Weather Bureau, 1896; Capt. J. C. Sanford, United States Engineer, Secretary Missouri River Commission; Capt. J. S. Hill; Dr. J. R Mudd.

NOTE.—Compared with Keokuk, Iowa, for interpolation for twenty years' period.

No. 126.—ST. CLAIR FLATS LIGHT-HOUSE, LAKE ST. CLAIR, MICHIGAN.

[42° 32′ latitude north. 82° 41′ longitude west.]

Year.	Opened.	Closed.	Year.	Opened.	Closed.	Year.	Opened.	Closed.
1874	Mar 20	Dec. 8	1882	Mar. 15	Dec. 8	1890	Mar. 30	Dec. 2
1875	Apr. 11	Dec. 12	1883	Apr. 17	Dec. 20	1891	Apr. 25	Dec. 20
1876	Apr. 6	Dec. 8	1884	Mar. 30	Dec. 18	1892	Apr. 4	Dec. 12
1877	Apr 17	Dec. 15	1885	Apr. 19	Dec. 31	1893	Apr. 4	Dec. 17
1878	Mar. 21	Dec. 17	1886	Apr. 27	Dec. 15	1894	Mar. 20	Dec. 28
1879	Apr. 3	Dec. 13	1887	Apr. 5	Dec. 12	1895	Apr. 6	Dec. 16
1880	Mar. 13	Dec. 6	1888	Apr. 7	Dec. 6	1896	Apr. 4	.....
1881	Apr. 19	Dec. 31	1889	Mar. 28	Dec. 31			

Average date of opening, April 4; average date of closing, December 15; average number of days closed, 110.

Authority: Commander William Folger, U. S. N., Eleventh light-house district.

No. 127.—ST. CROIX RIVER, LAKE HUDSON, WISCONSIN.

[44° 55′ latitude north. Altitude, 667 feet. 92° 45′ longitude west.]

Year.	Opened.	Closed.	Year.	Opened.	Closed.	Year.	Opened.	Closed.
1863	Apr. 7	Nov. 20	1875	Apr. 12	Nov. 15	1887	Apr. 13	Nov. 26
1864	Apr. 5	Nov. 12	1876	Apr. 18	Nov. 25	1888	Apr. 24	Dec. 3
1865	Apr. 8	Nov. 20	1877	Apr. 8	Dec. 31	1889	Apr. 8	Nov. 25
1866	Apr. 10	Nov. 25	1878	Apr. 2	Nov. 20	1890	Apr. 15	Dec. 2
1867	Apr. 10	Nov. 24	1879	Apr. 4	Nov. 17	1891	Apr. 17	Nov. 24
1868	Mar. 26	Nov. 25	1880	Apr. 1	Nov. 13	1892	Apr. 5	Nov. 24
1869	Apr. 9	Nov. 13	1881	Apr. 12	Nov. 14	1893	Apr. 21	Nov. 24
1870	Apr. 5	Nov. 21	1882	Apr. 3	Nov. 23	1894	Apr. 4	Nov. 21
1871	Mar. 29	Nov. 22	1883	Apr. 12	Nov. 12	1895	Apr. 11	Nov. 25
1872	Apr. 8	Nov. 20	1884	Apr. 15	Nov. 24	1896	Apr. 15	.....
1873	Apr. 5	Nov. 25	1885	Apr. 20	Dec. 5			
1874	Apr. 15	Nov. 15	1886	Apr. 15	Nov. 24			

Average date of opening, April 9; average date of closing, November 20; average number of days closed, 140.

Authorities: Annual Report of the Chief of Engineers, U. S. A., 1884; Mr. A. O. Powell, assistant engineer, United States Engineers, St. Paul, Minn., 1896.

No. 128.—ST. JOSEPH, MO.

[39° 45′ latitude north. Altitude, 790 feet. 94° 52′ longitude west.]

Year.	Opened.	Closed.	Year.	Opened.	Closed.	Year.	Opened.	Closed.
1875	.....	.....	1882	Feb. 6	Dec. 7	1891	Mar. 2	Jan. 3
1876	.....	Jan. 11	1883	Mar. 3	Dec. 18		Mar. 16	Mar. 3
1876	.....	Jan. 30	1884	Mar. 11	Nov. 25		Nov. 29	Nov. 18
1876	Jan. 15	Dec. 1	1884	Nov. 27	.....		Dec. 3	Nov. 30
	Feb. 9		1885	.....	Jan. 2		Dec. 11	Dec. 8
1877	Feb. 10	Nov. 30	1885	Mar. 12	Dec. 10		Dec. 31	Dec. 26
1877	Dec. 12	.....	1885	Dec. 27	.....	1892	Feb. 9	Jan. 3
1878	.....	Jan. 4	1886	.....	Jan. 6		Mar 23	Mar. 20
1878	.....	Dec. 14	1886	Feb. 20	Nov. 29			Dec. 26
1878	Jan. 19	.....		Dec. 10	Dec. 19	1893	Jan. 1	Jan. 2
1879	.....	Mar. 20	1887	Mar. 8	(Dec. 7)		Mar. 5	Dec. 1
1879	Feb. 23	Dec. 11	1888	(Mar. 16)	.....		Dec. 22	
	Mar. 24		1889	.....	Feb. 17	1894	Feb. 17	Jan. 30
1880	Jan. 8	Jan. 30	1889	(Feb. 28)	.....		Dec. 6	Dec. 3
	Feb. 11	Mar. 14	1890	.....	Jan. 13			Dec. 28
	Mar. 20		1890	.....	Feb. 20	1895	Feb. 27	Nov. 27
1881	Mar. 15	Nov. 21		Feb. 3	.....	1896	Feb. 14	.....
1881	Dec. 1	.....	1890	Mar. 15	Dec. 8			
1882	.....	Jan. 1		Dec. 24	.....			

Average date of opening, February 19; average date of closing, December 19; average number of days closed, 62.

Authorities: Report of the United States Missouri River Commission, 1887-1890; Missouri River Commission "Stages of the Missouri River," 1894; United States Weather Bureau, 1896.

NOTE.—Compared with Nebraska City, Nebr., for interpolation for twenty years' period.

No. 129.—ST. LOUIS, MO.

[38° 38′ latitude north. Altitude, 384 feet. 90° 12′ longitude west.]

Year.	Opened.	Closed.	Year.	Opened.	Closed.	Year.	Opened.	Closed.
1865	.....	Dec. 15	1877	Feb. 6	Open.	1887	Jan. 27	Dec. 19
1866	Jan. 12	Dec. 26	1878	Open.	Dec. 17	1888	Jan. 31	Open.
1867	Feb. 8	.....	1879	Jan. 31	Dec. 18	1889	Open.	Open.
1868	.....	Jan. 8	1880	Jan. 1	Nov. 18	1890	Open.	Open.
1868	Feb. 18	Open.	1881	Feb. 15	Open.	1891	Open.	.....
1869	Open.	Dec. 21	1882	Open.	Dec. 7	1892	.....	Jan. 9
1869	Dec. 28	.....	1883	Jan. 30	Dec. 19	1892	Feb. 1	Dec. 20
1870	.....	Dec. 21	1884	Feb. 5	Dec. 19	1893	Feb. 15	Open.
1871	Jan. 23	Nov. 29		Dec. 30		1894	Open.	.....
1872	Feb. 24	Nov. 29	1885	.....	Dec. 10	1895	.....	Jan. 1
1873	Jan. 20	Open.	1885	Dec. 23	.....	1895	Mar. 1	Open.
1874	Open.	Dec. 30	1886	.....	Jan. 7	1896	Open.	.....
1875	Feb. 27	Open.	1886	Feb. 10	Dec. 1			
1876	Open.	Dec. 8		Dec. 14	Dec. 24			

Average date of opening, January 20; average date of closing, December 19; average number of days closed, 32.

Authorities: Report of the Chief Signal Officer; Annual Statement of the Trade and Commerce of St. Louis, Mo., 1895.

No. 130.—ST. MARYS FALLS CANAL LIGHT-HOUSE, MICHIGAN.

[46° 30′ latitude north. 84° 23′ longitude west.]

Year.	Opened.	Closed.	Year.	Opened.	Closed.	Year.	Opened.	Closed.
1874	May 11	Dec. 2	1882	Apr. 21	Dec. 2	1890	Apr. 20	Dec. 4
1875	May 1	Dec. 5	1883	May 1	Dec. 10	1891	Apr. 28	Dec. 8
1876	May 6	Nov. 30	1884	Apr. 27	Dec. 10	1892	Apr. 17	Dec. 7
1877	May 1	Nov. 30	1885	May 8	Dec. 7	1893	Apr. 30	Dec. 6
1878	Apr. 8	Nov. 30	1886	Apr. 25	Dec. 4	1894	Apr. 17	Dec. 17
1879	May 1	Nov. 5	1887	May 3	Dec. 4	1895	Apr. 27	Dec. 11
1880	Apr. 26	Nov. 16	1888	May 8	Dec. 5	1896	Apr. 20	.....
1881	May 7	Dec. 7	1889	Apr. 14	Dec. 5			

Average date of opening, April 27; average date of closing, December 2; average number of days closed, 146.

Authority: Commander William Folger, U. S. N., Eleventh light-house district.

No. 131.—ST. VINCENT, MINN.

[48° 56′ latitude north. Altitude, 748 feet. 97° 14′ longitude west.]

Year.	Opened.	Closed.	Year.	Opened.	Closed.	Year.	Opened.	Closed.
1871	Apr. 16	Nov. 30	1880	Apr. 24	Nov. 12	1889	(Mar.28)	Nov. 16
1872	Apr. 20	Oct. 28	1881	Apr. 25	Nov. 13	1890	(Apr.16)	Dec. 1
1873	Apr. 25	Nov. 7	1882	Apr. 17	Nov. 11	1891	(Apr.16)	Nov. 17
1874	Apr. 19	Oct. 17	1883	Apr. 21	Nov. 11	1892	Apr. 21	Nov. 8
1875	Apr. 21	Nov. 4	1884	Apr. 19	Nov. 22	1893	Apr. 30	Nov. 18
1876	Apr. 22	Oct. 10	1885	Apr. 21	Nov. 13	1894	Apr. 19	Nov. 10
1877	Apr. 23	Dec. 1	1886	Apr. 15	Nov. 24	1895	Apr. 8	Nov. 6
1878	Mar. 18	Oct. 30	1887	Apr. 17	(Nov.18)	1896	Apr. 16	.....
1879	Apr. 12	Nov. 2	1888	Apr. 19	Nov. 26			

Average date of opening, April 18; average date of closing, November 10; average number of days closed, 159.

Authorities: United States Weather Bureau, 1896; Mr. N. G. Deacon, New Era, St. Vincent.

NOTE.—Compared with Winnipeg, Manitoba, for interpolation for twenty years' period.

No. 132.—STRAITS OF MACKINAC.

[45° 48′ latitude north. Altitude, 579.6 feet. 84° 46′ longitude west.]

Year.	Opened.	Closed.	Year.	Opened.	Closed.	Year.	Opened.	Closed.
1853	Apr. 17	.....	1868	Apr. 19	.....	1882	Apr. 3	Dec. 30
1854	Apr. 25	.....	1869	Apr. 28	.....	1883	Apr. 28	Dec. 25
1855	May 1	.....	1870	Apr. 18	.....	1884	Apr. 25	Dec. 21
1856	May 2	.....	1871	Apr. 2	.....	1885	May 5	Jan. 8
1857	May 1	.....	1872	Apr. 28	.....	1886	Apr. 24	Jan. 15
1858	Apr. 6	.....	1873	May 1	.....	1887	Apr. 17	Dec. 27
1859	Apr. 4	.....	1874	Apr. 29	.....	1888	May 4	Dec. 30
1860	Apr. 13	.....	1875	Apr. 28	.....	1889	Apr. 6	Jan. 1
1861	Apr. 25	.....	1876	Apr. 28	(Dec. 21)	1890	Apr. 9	Jan. 5
1862	Apr. 18	.....	1877	Apr. 18	.....	1891	Apr. 17	Dec. 26
1863	Apr. 17	.....	1878	.....	(Jan. 17)	1892	Apr. 9	Dec. 24
1864	Apr. 28	.....	1878	Mar. 15	(Dec. 19)	1893	Apr. 17	Jan. 1
1865	Apr. 21	.....	1879	Apr. 22	(Dec. 24)	1894	Mar. 29	Dec. 31
1866	Apr. 28	.....	1880	Apr. 4	Dec. 15	1895	Apr. 11	Jan. 1
1867	Apr. 23	.....	1881	May 2	Feb. 1	1896	Apr. 16	.....

Average date of opening, April 17; average date of closing, January 9; average number of days closed, 98.

Authorities: Monthly Weather Review, United States; Reports of the Chief Signal Officer of the United States; Report of the New York Produce Exchange; Mr. Wm. Fitch, general manager Duluth, South Shore and Atlantic Railway; Mr. J. H. P. Hughart, general manager Grand Rapids and Indiana Railroad.

NOTE.—Compared with Alpena, Mich., for interpolation for twenty years' period.

No. 133.—STURGEON POINT LIGHT-HOUSE, MICHIGAN.

[44° 47′ latitude north. Altitude, 579.60 feet. 83° 15′ longitude west.]

Year.	Opened.	Closed.	Year.	Opened.	Closed.	Year.	Opened.	Closed.
1874	Mar. 20	Dec. 15	1882	Mar. 10	Dec. 15	1890	Mar. 17	Dec. 20
1875	Apr. 19	Dec. 12	1883	Apr. 12	Dec. 20	1891	Apr. 6	Dec. 17
1876	Apr. 12	Dec. 13	1884	Apr. 5	Dec. 18	1892	Apr. 5	Dec. 19
1877	Apr. 13	Dec. 18	1885	Apr. 20	Dec. 15	1893	Apr. 10	Dec. 15
1878	Mar. 10	Dec. 16	1886	Mar. 29	Dec. 16	1894	Mar. 19	Dec. 23
1879	Apr. 6	Dec. 18	1887	Apr. 11	Dec. 12	1895	Apr. 2	Dec. 21
1880	Mar. 6	Dec. 11	1888	Apr. 5	Dec. 18	1896	Apr. 6	.....
1881	Apr. 27	Dec. 29	1889	Mar. 11	Dec. 31			

Average date of opening, April 2; average date of closing, December 18; average number of days closed, 105.

Authority: Commander William Folger, U. S. N., Eleventh light-house district.

No. 134.—SYDNEY, NOVA SCOTIA.

[46° 09′ latitude north. 60° 13′ longitude west.]

Year.	Opened.	Closed.	Year.	Opened.	Closed.	Year.	Opened	Closed.
1867	Apr. 23	.....	1881	Apr. 29	.....	1889	Apr. 4	.....
1868	May 5	.....	1882	.....	Jan. 5	1890	.....	Jan. 9
1869	.....	Jan. 19	1882	Apr. 24	.....	1890	Apr. 11	.....
1869	Apr. 21	.....	1883	.....	Jan. 6	1891	.....	Jan. 9
1870	Apr. 11	.....	1883	Apr. 10	.....	1891	Apr. 29	.....
1871	Apr. 21	.....	1884	.....	Jan. 3	1892	.....	Feb. 4
1872	May 3	Dec. 31	1884	Apr. 26	.....	1892	Apr. 26	.....
1873	Apr. 28	.....	1885	.....	Jan. 19	1893	.....	Jan. 10
1874	May 1	.....	1885	May 4	.....	1893	Apr. 26	.....
1875	May 12	.....	1886	.....	Jan. 14	1894	.....	Jan. 10
1876	May 7	Dec. 23	1886	Apr. 19	.....	1894	May 2	.....
1877	Apr. 7	.....	1887	.....	Jan. 7	1895	.....	Jan. 27
1878	.....	Jan. 8	1887	Apr. 26	.....	1895	Apr. 25	.....
1878	Apr. 6	.....	1888	.....	Jan. 10	1896	.....	Jan. 23
1879	.....	Jan. 16	1888	Apr. 25	.....	1896	Mar. 28	.....
1879	Apr. 19	Dec. 30	1889	.....	Feb. 8			
1880	May 6	Dec. 31						

Average date of opening, April 22; average date of closing, January 13; average number of days closed, 99.

Authorities: General Report Public Works, Canada, 1867–1882; Annual Report of the Department of Railways and Canals, Dominion of Canada, 1883–1889; Department of Public Works, Dominion of Canada, 1896.

No. 135.—SHERWOOD POINT LIGHT-HOUSE, WISCONSIN.

[44° 53′ latitude north. Altitude, 579.60 feet. 87° 26′ longitude west.]

Year.	Opened.	Closed.	Year.	Opened.	Closed.	Year.	Opened.	Closed.
1887	Apr. 26	Dec. 23	1892	Apr. 6	Dec. 18	1895	Apr. 1	Dec. 31
1888	Apr. 29	Dec. 31	1893	Apr. 14	Dec. 15	1896	Apr. 9	.....
1889	Apr. 8	Dec. 31	1894	Mar. 21	.....			
1890	Apr. 13	Dec. 24	1895	.....	Jan. 8			
1891	Apr. 21	Dec. 31						

Average date of opening, April 10; average date of closing, December 27; average number of days closed, 104.

Authority: Commander J. H. Dayton, U. S. N., Ninth light-house district.

NOTE.—Compared with Green Bay, Wis., for interpolation for twenty years' period.

No. 136.—TAWAS LIGHT-HOUSE, LAKE HURON, MICHIGAN.

[44° 15′ latitude north. Altitude, 579.60 feet. 83° 27′ longitude west.]

Year.	Opened.	Closed.	Year.	Opened.	Closed.	Year.	Opened.	Closed.
1874	Mar. 18	Dec. 16	1882	Mar. 4	Dec. 13	1890	Mar. 14	Dec. 27
1875	Apr. 15	Dec. 11	1883	Apr. 16	Dec. 18	1891	Apr. 1	Dec. 27
1876	Apr. 7	Nov. 9	1884	Apr. 10	Dec. 10	1892	Apr. 4	Dec. 19
1877	Apr. 10	Dec. 29	1885	Apr. 25	Dec. 14	1893	Apr. 8	Dec. 12
1878	Mar. 9	Dec. 14	1886	Mar. 30	Dec. 8	1894	Mar. 18	Dec. 20
1879	Apr. 4	Dec. 15	1887	Apr. 16	Dec. 23	1895	Apr. 8	Dec. 30
1880	Mar. 2	Dec. 10	1888	Apr. 5	Dec. 22	1896	Apr. 5	.....
1881	Apr. 26	Dec. 31	1889	Mar. 19	Dec. 31			

Average date of opening, April 2; average date of closing, December 18; average number of days closed, 105.

Authority: Commander William Folger, U. S. N., Eleventh light-house district.

No. 137.—TERRE HAUTE, IND.

[39° 27′ latitude north. Altitude, 447 feet. 87° 24′ longitude west.]

Year.	Opened.	Closed.	Year.	Opened.	Closed.	Year.	Opened.	Closed.
1883	Feb. 18	Jan. 2	1887	Feb. 7	Nov. 28	1892	Mar. 16	Dec. 22
		Dec. 20	1888	Jan. 17	Open.	1893	Feb. 15	Nov. 24
1884	Jan. 24	Dec. 16	1889	Open.	Nov. 30	1894	Feb. 28	Dec. 27
1885	Feb. 22	Dec. 21	1890	Feb. 15	Dec. 26	1895	Feb. 26	Dec. 4
1886	Feb. 11	Dec. 27	1891	Feb. 19	Nov. 27	1896	Feb. 24	.....

Average date of opening, February 16; average date of closing, December 14; average number of days closed, 64.

Authority: Mr. Joseph McKinley.

No. 138.—THE ARSENAL, CENTRAL PARK, NEW YORK, N. Y.

Year.	Opened.	Closed.	Year.	Opened.	Closed.	Year.	Opened.	Closed.
1858	.....	Dec. 29	1874	Feb. 12	Dec. 26	1887	Feb. 6	.....
1859	Mar. 6	Dec. 24	1875	Feb. 22	Open.	1888	.....	Jan. 16
1860	Feb. 20	Dec. 14	1876	Open.	Dec. 24	1888	Feb. 22	.....
1861	Feb. 10	Dec. 20	1877	Jan. 31	.....	1889	.....	Feb. 15
1862	Mar. 8	Dec. 22	1878	.....	Jan. 7	1889	Feb. 26	Open.
1863	Feb. 26	Dec. 11	1878	Jan. 9	Dec. 26	1890	Open.	.....
1864	Feb. 21	Dec. 21	1879	Mar. 2	Open.	1891	.....	Jan. 8
1865	Feb. 24	.....	1880	Open.	Dec. 23	1891	Jan. 24	.....
1866	.....	Jan. 8	1881	Feb. 22	.....	1892	.....	Jan. 27
1866	Feb. 18	Dec. 15	1882	.....	Jan. 31	1892	Feb. 14	Dec. 30
1867	Feb. 2	Dec. 15	1882	Feb. 10	Dec. 20	1893	Feb. 12	Open.
1868	Mar. 6	Dec. 17	1883	Feb. 10	.....	1894	Open.	.....
1869	Feb. 8	.....	1884	.....	Jan. 6	1895	.....	Jan. 3
1870	.....	.....	1884	Feb. 3	.....	1895	Feb. 27	.....
1871	.....	.....	1885	.....	Jan. 27	1896	.....	Jan. 7
1872	.....	Dec. 16	1885	Feb. 24	.....	1896	Jan. 23	.....
1873	Mar. 8	.....	1886	.....	Jan. 14			
1874	.....	Jan. 26	1886	Feb. 8	Dec. 30			

Average date of opening, February 15; average date of closing, January 5; average number of days closed, 41.

NOTE.—This table is made from data furnished by New York Meteorology, 1850-1863, second series, by F. B. Hough and by Mr. William Leary, secretary of commissioners, Department of Public Parks. The data is the dates of the first and last days of skating in the park.

No. 139.—THUNDER BAY ISLAND LIGHT-HOUSE, MICHIGAN.

[45° 02′ latitude north. Altitude, 579.60 feet. 83° 11′ longitude west.]

Year.	Opened.	Closed.	Year.	Opened.	Closed.	Year.	Opened.	Closed.
1874	Mar. 20	Dec. 13	1882	Mar. 20	Dec. 14	1890	Mar. 22	Dec. 14
1875	Apr. 15	Dec. 15	1883	Apr. 14	Dec. 12	1891	Apr. 1	Dec. 17
1876	Apr. 15	Dec. 14	1884	Apr. 8	Dec. 10	1892	Apr. 7	Dec. 31
1877	Apr. 15	Dec. 16	1885	Apr. 22	Dec. 12	1893	Apr. 11	Dec. 17
1878	Mar. 16	Dec. 15	1886	Apr. 1	Dec. 9	1894	Mar. 13	Dec. 24
1879	Apr. 6	Dec. 16	1887	Apr. 13	Dec. 10	1895	Apr. 11	Dec. 19
1880	Mar. 1	Dec. 10	1888	Apr. 15	Dec. 15	1896	Apr. 10	.....
1881	May 2	Dec. 13	1889	Mar. 27	Dec. 14			

Average date of opening, April 5; average date of closing, December 14; average number of days closed, 112.

Authority: Commander William Folger, U. S. N., Eleventh light-house district.

No. 140.—TOLEDO, OHIO.

[41° 40′ latitude north. Altitude, 571.35 feet. 83° 34′ longitude west.]

Year.	Opened.	Closed.	Year.	Opened.	Closed.	Year.	Opened.	Closed.
1857	May 1	.....	1871	Mar. 16	Dec. 4	1885	Apr. 1	Dec. 7
1858	Apr. 6	.....	1872	Apr. 9	Nov. 29	1886	Mar. 23	Dec. 1
1859	Apr. 4	.....	1873	Mar. 28	Dec. 5	1887	Apr. 4	Dec. 15
1860	Apr. 18	.....	1874	Mar. 19	Dec. 9	1888	Mar. 29	Dec. 3
1861	Apr. 25	.....	1875	Apr. 13	Dec. 10	1889	Apr. 14	Dec. 7
1862	Apr. 13	.....	1876	Apr. 3	Dec. 5	1890	Apr. 1	Dec. 1
1863	Apr. 17	.....	1877	Apr. 17	Dec. 10	1891	Apr. 9	Dec. 16
1864	Apr. 23	.....	1878	Mar. 28	Dec. 18	1892	Apr. 15	Dec. 5
1865	Apr. 21	.....	1879	Apr. 7	Dec. 15	1893	Apr. 1	Dec. 5
1866	Apr. 29	.....	1880	Mar. 3	Dec. 1	1894	Mar. 24	Dec. 27
1867	Apr. 23	.....	1881	Apr. 7	Dec. 27	1895	Apr. 4	Nov. 27
1868	Apr. 19	.....	1882	Feb. 25	Dec. 16	1896	Mar. 21	.....
1869	Apr. 23	.....	1883	Apr. 9	Dec. 18			
1870	Apr. 20	.....	1884	Mar. 29	Dec. 15			

Average date of opening, April 1; average date of closing, December 10; average number of days closed, 112.

Authorities: Report of Toledo Board of Trade; Reports of the Chief Signal Officer, Mr. C. Randolph Brand.

No. 141.—TORONTO, ONTARIO.

[43° 38′ latitude north. Altitude, 244.53 feet. 79° 29′ longitude west.]

Year.	Opened.	Closed.	Year.	Opened.	Closed.	Year.	Opened.	Closed.
1833	Apr. 4	.....	1856	Apr. 17	Dec. 22	1879	Mar. 25	Dec. 24
1834	Mar. 14	.....	1857	Feb. 27	Dec. 30	1880	Feb. 19	Dec. 8
1835	Mar. 30	Dec. 1	1858	Mar. 4	Dec. 21	1881	Apr. 1	.....
1836	Apr. 25	.....	1859	Feb. 7	Dec. 30	1882	.....	Jan. 2
1837	Apr. 16	Dec. 14	1860	Jan. 10	Dec. 31	1882	Feb. 13	Dec. 9
1838	Apr. 2	.....	1861	Jan. 2	Dec. 31	1883	Apr. 13	Dec. 21
1839	Apr. 2	.....	1862	Jan. 2	Dec. 30	1884	Mar. 30	Dec. 19
1840	Mar. 28	Dec. 6	1863	Jan. 7	Dec. 21	1885	Apr. 25	.....
1841	Apr. 12	Dec. 18	1864	Feb. 3	Dec. 29	1886	.....	Jan. 8
1842	Mar. 17	.....	1865	Mar. 25	Dec. 30	1886	Mar. 20	Dec. 4
1843	Apr. 23	Dec. 13	1866	Apr. 3	Dec. 26	1887	Apr. 12	Dec. 24
1844	.....	Dec. 18	1867	Mar. 28	Dec. 9	1888	Apr. 7	Dec. 20
1845	.....	Dec. 3	1868	Apr. 6	Dec. 12	1889	Mar. 15	Dec. 27
1846	Apr. 8	Dec. 14	1869	Apr. 1	Dec. 3	1890	Mar. 5	Dec. 24
1847	Apr. 19	Dec. 26	1870	Apr. 3	Dec. 24	1891	Mar. 22	.....
1848	Mar. 31	Dec. 25	1871	Mar. 11	Nov. 30	1892	.....	Jan. 5
1849	Mar. 29	Dec. 26	1872	Apr. 12	Dec. 10	1892	Mar. 31	Dec. 22
1850	Apr. 3	Dec. 13	1873	Apr. 14	Nov. 26	1893	Apr. 7	Dec. 30
1851	Mar. 24	Dec. 13	1874	Mar. 16	Dec. 20	1894	Mar. 17	Dec. 23
1852	Apr. 7	Jan. 5	1875	Apr. 16	Nov. 30	1895	Apr. 5	Dec. 9
1853	.....	.....	1876	Apr. 11	Dec. 9	1896	Mar. 28	.....
1854	.....	Dec. 8	1877	Mar. 25	Dec. 19			
1855	Apr. 2	Dec. 19	1878	Mar. 9	Dec. 16			

Average date of opening, March 21; average date of closing, December 19; average number of days closed, 92.

Authorities: General Report Public Works, Canada, 1867-1882; Report of the Department of Railways and Canals, Dominion of Canada, 1883-1889; Department of Public Works, Dominion of Canada, 1896.

No. 142.—TURNERS FALLS, MASS.—CONNECTICUT RIVER.

[42° 34′ latitude north. 72° 34′ longitude west.]

Year.	Opened.	Closed.	Year.	Opened.	Closed.	Year.	Opened.	Closed.
1884	.....	Dec. 15	1889	Mar. 6	Dec. 8	1894	Apr. 30	Dec. 4
1885	Mar. 10	Dec. 5	1890	Mar. 9	Dec. 7	1895	Mar. 4	Dec. 11
1886	Apr. 29	Dec. 20	1891	Mar. 3	Dec. 10	1896	Mar. 7	.....
1887	Mar. 10	Dec. 15	1892	Mar. 1	Dec. 12			
1888	Mar. 15	Dec. 10	1893	Mar. 9	Dec. 2			

Average date of opening, March 16; average date of closing, December 9; average number of days closed, 97.

Authority: Mr. F. M. Stoughton.

NOTE.—Compared with Hartford, Conn., for interpolation for twenty years' period.

No. 143.—WAGOSHANCE LIGHT-HOUSE, MICHIGAN.

[45° 47 latitude north. Altitude, 579.60 feet. 85° 05 longitude west.]

Year.	Opened.	Closed.	Year.	Opened.	Closed.	Year.	Opened.	Closed.
1887	Apr. 16	Dec. 7	1891	Apr. 8	Dec. 10	1895	Apr. 10	Dec. 9
1888	Apr. 28	Dec. 8	1892	Apr. 1	Dec. 10	1896	Apr. 19	.....
1889	Mar. 24	Dec. 31	1893	Apr. 9	Dec. 13			
1890	Apr. 4	Dec. 9	1894	Apr. 6	Dec. 11			

Average date of opening, April 9; average date of closing, December 12; average number of days closed, 118.

Authority: Commander J. H. Dayton, U. S. N., Ninth light-house district.

NOTE.—Compared with Alpena, Mich., for interpolation for twenty years' period.

No. 144.—WHITEHALL, N. Y.

[43° 34′ latitude north. Altitude, 95.03 feet. 73° 24′ longitude west.]

Year.	Opened.	Closed.	Year.	Opened.	Closed.	Year.	Opened.	Closed.
1858	Apr. 10	Dec. 4	1872	.....	.....	1885	Apr. 25	Jan. 29
1859	Apr. 9	Dec. 3	1873	Apr. 28	Nov. 22	1886	Apr. 15	Jan. 24
1860	Apr. 7	Dec. 1	1874	Apr. 11	Nov. 30	1887	May 1	{Jan. 9
1861	Apr. 20	Dec. 7	1875	Apr. 30	Jan. 16			{Nov. 30
1862	Apr. 29	Dec. 6	1876	Apr. 24	Feb. 2	1888	May 1	Nov. 30
1863	Apr. 28	Nov. 26	1877	Apr. 5	Jan. 15	1889	Apr. 24	Nov. 30
1864	Apr. 11	Dec. 12	1878	Mar. 1	Jan. 29	1890	May 1	Dec. 4
1865	Apr. 15	Dec. 8	1879	Apr. 22	Jan. 29	1891	Apr. 27	Dec. 30
1866	Apr. 14	Dec. 15	1880	Mar. 7	Feb. 2	1892	Apr. 28	Dec. 4
1867	Apr. 22	Nov. 25	1881	Apr. 21	Jan. 16	1893	Apr. 24	Dec. 3
1868	Apr. 16	Dec. 2	1882	{Feb. 5	Feb. 4	1894	Apr. 26	Nov. 30
1869	Apr. 25	Dec. 2		{Mar. 4	Feb. 25	1895	Apr. 28	Dec. 2
1870	Apr. 16	Dec. 10	1883	Apr. 22	Jan. 26	1896	Apr. 1	.....
1871	Apr. 1	Nov. 30	1884	Apr. 19	Jan. 8			

Average date of opening, April 11; average date of closing, December 17; average number of day closed, 115.

Authorities: 1858-1875, Mr. George Rushlow, general manager Champlain Transportation Company; 1875-1887, Postmaster, Whitehall, 1896; 1887-1895, Commander A. S. Snow, inspector Third light-house district; 1896, Postmaster, Whitehall, 1896.

No. 145—WINDMILL POINT LIGHT-HOUSE, LAKE ST. CLAIR, MICHIGAN.

[42° 21′ latitude north. 82° 56′ longitude west.]

Year.	Opened.	Closed.	Year.	Opened.	Closed.	Year.	Opened.	Closed.
1874	Mar. 18	Dec. 18	1882	Mar. 3	Dec. 11	1890	Mar. 22	Dec. 16
1875	Apr. 9	Dec. 18	1883	Apr. 16	Dec. 20	1891	Apr. 22	Dec. 16
1876	Apr. 1	Dec. 10	1884	Mar. 30	Dec. 18	1892	Apr. 4	Dec. 27
1877	Apr. 12	Dec. 31	1885	Apr. 20	Dec. 31	1893	Apr. 5	Dec. 15
1878	Mar. 18	Dec. 21	1886	Apr. 28	Dec. 16	1894	Mar. 14	Dec. 28
1879	Apr. 1	Dec. 22	1887	Apr. 3	Dec. 22	1895	Apr. 6	Dec. 18
1880	Mar. 3	Dec. 18	1888	Apr. 5	Dec. 20	1896	Apr. 2	.....
1881	Apr. 16	Dec. 31	1889	Mar. 26	Dec. 31			

Average date of opening, April 2; average date of closing, December 21; average number of days closed, 102.

Authority: Commander William Folger, U. S. N., Eleventh light-house district.

No. 146.—WINDSOR, ONTARIO.

[42° 19′ latitude north. Altitude, 573.86 feet. 83° 02′ longitude west.]

Year.	Opened.	Closed.	Year.	Opened.	Closed.	Year.	Opened.	Closed.
1867	Feb. 23	Dec. 11	1877	Apr. 1	Dec. 31	1887	Jan. 5	Dec. 16
1868	Mar. 15	Dec. 10	1878	May 1	Dec. 31	1888	Open.	Open.
1869	Apr. 5	Dec. 17	1879	Apr. 3	Dec. 24	1889	Open.	Open.
1870	Apr. 7	Dec. 11	1880	Mar. 1	Dec. 3	1890	Open.	Open.
1871	Mar. 8	Dec. 8	1881	Apr. 15	Dec. 31	1891	Open.	Open.
1872	Apr. 1	Dec. 7	1882	Mar. 1	Dec. 18	1892	Open.	Dec. 17
1873	Apr. 1	Dec. 15	1883	Mar. 9	Dec. 17	1893	Apr. 18	Open.
1874	Mar. 10	Dec. 28	1884	Mar. 15	Dec. 17	1894	Open.	Open.
1875	Apr. 9	Dec. 4	1885	Jan. 14	Dec. 9	1895	Open.	Dec. 5
1876	Jan. 1	Dec. 4	1886	Apr. 28	Dec. 27	1896	Mar. 23	.....

Average date of opening, February 26; average date of closing, December 16; average number of days closed, 72.

Authority: Department of Public Works, Dominion of Canada, 1896.

No. 147.—WINNEPEG, MANITOBA.

[49° 52′ latitude north. Altitude, 724 feet. 97° 08′ longitude west.]

Year.	Opened.	Closed	Year.	Opened.	Closed.	Year.	Opened.	Closed.
1874	.....	Nov. 5	1882	Apr. 19	Nov. 13	1890	Apr. 21	Nov. 3
1875	Apr. 30	Nov. 2	1883	.....	Nov. 10	1891	Apr. 17	Nov. 15
1876	Apr. 22	Nov. 5	1884	Apr. 24	Nov. 1	1892	Apr. 20	Nov. 30
1877	Apr. 22	Nov. 1	1885	Apr. 25	Nov. 2	1893	May 8	Nov. 13
1878	Mar. 22	Oct. 30	1886	Apr. 14	Nov. 4	1894	Apr. 21	Nov. 9
1879	Apr. 15	Nov. 1	1887	Apr. 25	Nov. 1	1895	Apr. 8	Nov. 25
1880	Apr. 26	.....	1888	Apr. 28	Nov. 15	1896	Apr. 26	.....
1881	.....	Nov. 5	1889	Apr. 25	Nov. 19			

Average date of opening, April 21; average date of closing, November 8; average number of days closed, 164.

Authorities: Annual Reports, Department of Railways and Canals, Dominion of Canada, 1883; Department of Public Works, Canada, 1896.

No. 148.—YANKTON, S. DAK.

[42° 54′ latitude north. Altitude, 1,150 feet. 97° 28′ longitude west.]

Year.	Opened.	Closed.	Year.	Opened.	Closed.	Year.	Opened.	Closed.
1874	Mar. 18	Nov. 26	1884	Mar. 22	Dec. 14	1892	Apr. 29	Nov. 24
1875	Apr. 3	Nov. 21	1885	Mar. 14	Dec. 8	1893	Mar. 29	Dec. 11
1876	Apr. 6	Nov. 15	1886	Mar. 18	Dec. 1	1894	Mar. 10	Dec. 24
1877	Feb. 22	Dec. 24	1887	Apr. 4	Nov. 23	1895	Mar. 18	Nov. 30
1878	Feb. 19	Dec. 14	1888	Mar. 31	Dec. 6	1896	Mar. 1	.....
1879	Mar. 23	Dec. 3	1889	Mar. 10	.....			
1880	Feb. 24	Nov. 17	1890	.....	Jan. 13			
1881	Apr. 24	Nov. 18	1890	Mar. 23	.....			
1882	Mar. 17	Dec. 2	1891	.....	Jan. 2			
1883	Mar. 13	Dec. 16	1891	Apr. 1	Dec. 25			

Average date of opening, March 21; average date of closing, December 7; average number of days closed, 104.

Authorities: United States Weather Bureau, 1896; Mr. Ed. Palmer, city engineer.

No. 149.—YORK FACTORY, HAYES RIVER.

[57° 00′ latitude north. 92° 28′ longitude west.]

Year.	Opened.	Closed.	Year.	Opened.	Closed.	Year.	Opened.	Closed.
1828	June 1	Nov. 15	1852	May 16	Nov. 8	1872	May 16	Nov. 20
1829	May 10	Nov. 11	1853	May 26	Nov. 9	1873	May 14	Nov. 18
1830	May 17	Dec. 2		to 30.		1874	May 16	Nov. 20
1831	May 22	Nov. 28	1854	May 23	Nov. 16	1875	May 19	Nov. 15
1832	May 25	Nov. 26	1855	May 25	Nov. 24	1876	May 10	Nov. 24
1833	May 13	Nov. 22	1856	May 20	Nov. 19	1877	May 20	Nov. 15
1834	May 27	Nov. 20		to 22.				to 20.
1835	May 24	Nov. 18	1857	May 14	Nov. 17	1878	May 15	Nov. 3
1836	May 16	Nov. 29		to 19.		1879	May 3	Nov. 23
1837	May 11	Nov. 25	1858	May 24	Nov. 24	1880	May 26	Nov. 20
1838	May 23	Nov. 22	1859	May 13	Nov. 16	1881	.....	.....
1839	May 22	Nov. 19	1860	May 18	Nov. 19	1882	.....	.....
1840	May 12	Nov. 16	1861	May 22	Nov. 16	1883	.....	.....
1841	May 10	Nov. 13		to 28.		1884	.....	.....
1842	May 17	Nov. 11	1862	May 24	Nov. 24	1885	.....	.....
1843	May 29	Nov. 16		to 29.		1886	.....	.....
1844	May 13	Nov. 26	1863	May 22	Nov. 30	1887	.....	.....
	to 20.		1864	May 19	Nov. 26	1888	.....	.....
1845	May 22	Nov. 24	1865	May 16	Nov. 20	1889	.....	.....
1846	May 7	Nov. 25	1866	May 14	Nov. 28	1890	.....	.....
	to 9.		1867	May 23	Nov. 24	1891	.....	Nov. 14
1847	May 9	Nov. 15		to 28.		1892	May 24	.....
1848	May 21	Nov. 28	1868	May 24	Nov. 29	1893	a July 15	Nov. 4
1849	May 18	Nov. 27		to 31.		1894	May 20	.....
	to 24.		1869	May 25	Nov. 6	1895	.....	.....
1850	May 31	Nov. 28	1870	May 11	Nov. 27	1896	.....	.....
1851	May 31	Dec. 9	1871	May 12	Nov. 23			

a Ice in river August 1.

Average date of opening, May 19; average date of closing, November 19; average number of days closed, 181.

Authorities: Mr. Woods, York Factory, in Report of Minister of Public Works, Dominion of Canada, 1884; Department of Public Works, Dominion of Canada, 1896.

No. 150.—ZANESVILLE, OHIO, MUSKINGUM RIVER.

[39° 59′ latitude north. Altitude, 678 feet. 82° 00′ longitude west.]

Year.	Opened.	Closed.	Year.	Opened.	Closed.	Year.	Opened.	Closed.
1888	Feb. 21	Jan. 1	1891	Jan. 29	Open.	1894	Feb. 21	Open.
1889	Mar. 4	Feb. 6	1892	Feb. 15	Jan. 7	1895	Mar. 5	Jan. 1
1890	Mar. 10	Jan. 1			Dec. 25	1896	Mar. 2	Jan. 3
		Dec. 19	1893	Mar. 1	Dec. 23			

Average date of opening, February 25; average date of closing, January 3; average number of days closed, 53.

Authority: Mr. Edmund Maeser, assistant engineer United States Engineer Office.

No. 151.—BEAUHARNOIS CANAL.

Year.	Opened.	Closed.	Year.	Opened.	Closed.	Year.	Opened.	Closed.
1845	Oct. 11	Nov. 26	1863	May 2	Dec. 4	1881	Apr. 25	Nov. 28
1846	Apr. 16	Nov. 29	1864	Apr. 24	Dec. 3	1882	Apr. 25	Dec. 4
1847	May 5	Nov. 28	1865	Apr. 25	Dec. 2	1883	Apr. 30	Dec. 1
1848	Apr. 12	Nov. 30	1866	Apr. 30	Dec. 8	1884	Apr. 26	Dec. 1
1849	Apr. 19	Dec. 8	1867	Apr. 29	Dec. 2	1885	May 3	Dec. 3
1850	Apr. 26	Dec. 4	1868	Apr. 27	Dec. 2	1886	May 1	Dec. 1
1851	Apr. 25	Nov. 25	1869	May 3	Nov. 3	1887	May 3	Dec. 1
1852	May 2	Dec. 13	1870	Apr. 28	Dec. 5	1888	May 1	Dec. 1
1853	Apr. 29	Nov. 24	1871	Apr. 19	Dec. 2	1889	Apr. 17	Nov. 30
1854	May 1	Dec. 2	1872	May 1	Dec. 2	1890	Apr. 21	Nov. 30
1855	May 1	Nov. 28	1873	May 1	Nov. 24	1891	Apr. 24	Dec. 1
1856	May 1	Dec. 1	1874	May 3	Nov. 25	1892	Apr. 30	Dec. 1
1857	May 2	Nov. 26	1875	May 3	Nov. 25	1893	May 1	Dec. 1
1858	Apr. 26	Nov. 26	1876	May 1	Nov. 29	1894	Apr. 3	Nov. 30
1859	Apr. 19	Nov. 29	1877	May 5	Dec. 6	1895	May 1	Nov. 30
1860	Apr. 19	Dec. 3	1878	Apr. 24	Dec. 6	1896	May 1	.....
1861	Apr. 24	Dec. 3	1879	May 1	Dec. 2			
1862	Apr. 30	Nov. 30	1880	Apr. 30	Nov. 28			

Average date of opening, April 26; average date of closing, December 3; average number of days closed, 146.

Authorities: General Report Public Works, Canada, 1867-1882; Annual Report of the Department of Railways and Canals, Dominion of Canada, 1883-1895; Department of Public Works, Dominion of Canada, 1896.

No. 152.—CARILLON CANAL.

Year.	Opened.	Closed.	Year.	Opened.	Closed.	Year.	Opened.	Closed.
1859	Apr. 29	Nov. 28	1872	May 2	Dec. 1	1885	May 7	Nov. 30
1860	Apr. 30	Nov. 29	1873	May 1	Nov. 18	1886	May 1	Nov. 30
1861	May 3	Nov. 29	1874	May 6	Nov. 15	1887	May 2	Nov. 30
1862	May 3	Nov. 30	1875	May 1	Nov. 20	1888	May 2	Dec. 2
1863	May 1	Dec. 2	1876	May 1	Nov. 30	1889	Apr. 26	Nov. 30
1864	May 2	Nov. 30	1877	Apr. 26	Dec. 5	1890	Apr. 26	Nov. 29
1865	May 1	Nov. 30	1878	Apr. 19	Sept. 6	1891	Apr. 23	Nov. 28
1866	May 3	Nov. 30	1879	May 1	Nov. 24	1892	Apr. 30	Nov. 30
1867	May 7	Nov. 30	1880	Apr. 29	Nov. 23	1893	May 1	Nov. 30
1868	May 2	Nov. 30	1881	Apr. 29	Nov. 26	1894	Apr. 23	Nov. 30
1869	May 3	Nov. 26	1882	Apr. 28	Nov. 24	1895	Apr. 29	Nov. 30
1870	Apr. 27	Dec 6	1883	Apr. 28	Nov. 27	1896	Apr. 27	.....
1871	May 1	Nov. 27	1884	Apr. 28	Nov. 24			

Average date of opening, April 30; average date of closing, November 28; average number of days closed, 153.

Authorities: General Report Public Works, Canada, 1867-1882; Annual Reports Department of Railways and Canals, Dominion of Canada, 1883-1895; Department of Public Works, Dominion of Canada, 1896.

No. 153.—CHAMBLY CANAL.

Year.	Opened.	Closed.	Year.	Opened.	Closed.	Year.	Opened.	Closed.
1843	.....	Nov. 17	1861	Apr. 25	Dec. 3	1879	May 5	Dec. 6
1844	Apr. 17	Nov. 27	1862	May 6	Dec. 4	1880	May 20	Nov. 25
1845	Apr. 21	Nov. 25	1863	May 1	Dec. 8	1881	May 2	Nov. 28
1846	Apr. 22	Nov. 21	1864	Apr. 25	Dec. 7	1882	May 2	Nov. 30
1847	May 18	Nov. 29	1865	Apr. 25	Dec. 8	1883	May 1	Nov. 30
1848	Apr. 19	.....	1866	May 1	Dec. 12	1884	May 5	Nov. 30
1849	May 21	Dec. 1	1867	May 1	Dec. 5	1885	May 4	Nov. 30
1850	Apr. 19	Dec. 5	1868	May 5	Dec. 2	1886	May 3	Dec. 1
1851	May 20	Nov. 19	1869	Apr. 28	Nov. 29	1887	May 5	Dec. 1
1852	Apr. 28	Dec. 14	1870	May 4	Dec. 3	1888	May 8	Nov. 22
1853	Apr. 28	Dec. 2	1871	May 3	Nov. 28	1889	Apr. 29	Nov. 28
1854	May 2	Dec. 2	1872	May 1	Dec. 2	1890	May 1	Nov. 24
1855	May 2	Nov. 29	1873	Apr. 25	Nov. 20	1891	May 1	Nov. 30
1856	Apr. 28	Dec. 1	1874	Apr. 25	Nov. 25	1892	May 2	Nov. 30
1857	May 7	Dec. 4	1875	May 1	Nov. 22	1893	May 8	Dec. 1
1858	Apr. 27	Nov. 19	1876	May 1	Nov. 28	1894	May 2	Nov. 30
1859	Apr. 15	Dec. 3	1877	May 1	Dec. 2	1895	May 1	Nov. 30
1860	Apr. 22	Dec. 2	1878	May 1	Dec. 6	1896	May 4	.....

Average date of opening, May 1; average date of closing, November 29; average number of days closed, 153.

Authorities: General Report Public Works, Canada, 1867-1882; Annual Reports Department of Railways and Canals, Dominion of Canada, 1883-1895; Mr. John C. Churchill, jr., C. E.; Department of Public Works, Dominion of Canada, 1896.

No. 154.—CHESAPEAKE AND OHIO CANAL.

Year.	Opened.	Closed.	Year.	Opened.	Closed.	Year.	Opened.	Closed.
1891	.....	Dec. 24	1893	Mar. 15	Dec. 20	1895	Mar. 18	Dec. 22
1892	Mar. 15	Dec. 24	1894	Mar. 18	Dec. 22	1896	Mar. 16	.....

Average date of opening, March 18; average date of closing, December 23; average number of days closed, 85.

Authority: Mr. G. L. Nicolson, general manager.

No. 155.—CHAMPLAIN CANAL.

[43° 23′ latitude north. Altitude (summit), 142.10 feet. 75° 30′ longitude west.]

Year.	Opened.	Closed.	Year.	Opened.	Closed.	Year.	Opened.	Closed.
1824	Apr. 30	Dec. 4	1849	May 1	Dec. 5	1873	May 15	Dec. 5
1825	Apr. 12	Dec. 5	1850	Apr. 22	Dec. 11	1874	May 5	Dec. 5
1826	Apr. 20	Dec. 18	1851	Apr. 15	Dec. 5	1875	May 18	Nov. 30
1827	Apr. 22	Dec. 18	1852	Apr. 20	Dec. 16	1876	May 4	Dec. 1
1828	Mar. 27	Dec. 20	1853	Apr. 20	Dec. 20	1877	May 8	Dec. 7
1829	May 2	Dec. 17	1854	May 1	Dec. 3	1878	Apr. 15	Dec. 7
1830	Apr. 20	Dec. 17	1855	May 1	Dec. 10	1879	May 8	Dec. 6
1831	Apr. 16	Dec. 1	1856	May 5	Dec. 4	1880	Apr. 16	Nov. 30
1832	Apr. 25	Dec. 21	1857	May 6	Dec. 15	1881	May 12	Dec. 8
1833	Apr. 19	Dec. 12	1858	Apr. 28	Dec. 8	1882	Apr. 11	Dec. 7
1834	Apr. 17	Dec. 12	1859	Apr. 15	Dec. 12	1883	May 8	Dec. 1
1835	Apr. 15	Nov. 30	1860	Apr. 25	Dec. 12	1884	May 6	Dec. 1
1836	Apr. 25	Nov. 26	1861	May 1	Dec. 10	1885	May 11	Dec. 1
1837	Apr. 20	Dec. 9	1862	May 1	Dec. 10	1886	May 3	Dec. 1
1838	Apr. 12	Nov. 25	1863	May 1	Dec. 9	1887	May 12	Dec. 1
1839	Apr. 20	Dec. 16	1864	Apr. 30	Dec. 9	1888	May 8	Dec. 3
1840	Apr. 20	Dec. 9	1865	May 1	Dec. 12	1889	May 11	Nov. 30
1841	Apr. 24	Nov. 28	1866	May 1	Dec. 12	1890	May 1	Nov. 30
1842	Apr. 20	Nov. 28	1867	May 6	Dec. 20	1891	May 1	Nov. 30
1843	May 1	Nov. 30	1868	May 4	Dec. 7	1892	May 5	Nov. 30
1844	Apr. 18	Nov. 26	1869	May 6	Dec. 18	1893	May 2	Nov. 30
1845	Apr. 15	Nov. 29	1870	May 10	Dec. 8	1894	May 4	Nov. 30
1846	Apr. 16	Nov. 25	1871	Apr. 21	Dec. 1	1895	May 5	Dec. 5
1847	May 1	Nov. 30	1872	May 13	Dec. 1	1896	May 1	.....
1848	May 1	Dec. 10						

Average date of opening, April 28; average date of closing, December 7; average number of days closed, 142.

Authorities: Annual Reports of the Department of Railways and Canals, Dominion of Canada, 1883–1895; Mr. O. C. Robinson; Mr. John C. Churchill, jr., C. E.; Mr. Thomas H. Canfield.

No. 156.—CORNWALL CANAL, CORNWALL.

[45° 01′ latitude north. 74° 44′ longitude west.]

Year.	Opened.	Closed.	Year.	Opened.	Closed.	Year.	Opened.	Closed.
1843	Apr. 10	Nov. 28	1861	Apr. 24	Dec. 12	1879	May 2	Dec. 9
1844	Apr. 24	Dec. 2	1862	May 1	Dec. 12	1880	Apr. 26	Dec. 6
1845	Apr. 28	Nov. 29	1863	May 4	Dec. 12	1881	Apr. 26	Dec. 10
1846	Apr. 20	Dec. 2	1864	Apr. 27	Dec. 10	1882	Apr. 25	Dec. 6
1847	May 1	Dec. 4	1865	Apr. 26	Dec. 13	1883	Apr. 28	Dec. 8
1848	Apr. 7	Dec. 9	1866	Apr. 30	Dec. 13	1884	Apr. 29	Dec. 8
1849	Apr. 7	Dec. 6	1867	May 1	Dec. 1	1885	May 8	Dec. 10
1850	Apr. 20	Dec. 7	1868	Apr. 27	Dec. 8	1886	May 1	Dec. 8
1851	Apr. 25	Dec. 12	1869	May 3	Dec. 7	1887	May 4	Dec. 4
1852	May 1	Dec. 16	1870	Apr. 28	Dec. 8	1888	May 2	Dec. 26
1853	Apr. 29	Dec. 14	1871	Apr. 20	Dec. 8	1889	Apr. 22	Dec. 11
1854	Apr. 30	Dec. 10	1872	May 2	Dec. 8	1890	Apr. 21	Dec. 4
1855	Apr. 30	Dec. 18	1873	Apr. 30	Dec. 4	1891	May 4	Dec. 15
1856	Apr. 28	Dec. 6	1874	Apr. 29	Dec. 4	1892	May 1	Dec. 4
1857	May 1	Dec. 12	1875	May 4	Dec. 6	1893	Apr. 30	Dec. 9
1858	Apr. 26	Dec. 7	1876	May 1	Dec. 8	1894	Apr. 23	Dec. 8
1859	Apr. 20	Dec. 7	1877	May 27	Dec. 8	1895	Apr. 29	Dec. 7
1860	Apr. 21	Dec. 10	1878	Apr. 22	Dec. 8	1896	Apr. 22	

Average date of opening, April 27; average date of closing, December 3; average number of days closed, 145.

Authorities: General Report Public Works, Canada, 1867–1882; Annual Report of the Department of Railways and Canals, Dominion of Canada, 1883–1896; Department of Public Works, Dominion of Canada, 1896.

No. 157.—DELAWARE AND HUDSON CANAL, RONDOUT, N. Y.

[41° 55′ latitude north. Altitude, 0.00 feet. 73° 58′ longitude west.]

Year.	Opened.	Closed.	Year.	Opened.	Closed.	Year.	Opened.	Closed.
1871	Apr. 4	Nov. 30	1880	Apr. 1	Nov. 25	1889	Mar. 25	Dec. 11
1872	Apr. 8	Dec. 5	1881	Apr. 1	Dec. 7	1890	Apr. 1	Dec. 5
1873	Apr. 11	Nov. 29	1882	Apr. 1	Dec. 6	1891	Apr. 1	Dec. 10
1874	Apr. 1	Nov. 30	1883	Apr. 10	Dec. 4	1892	Apr. 4	Dec. 8
1875	Apr. 12	Dec. 1	1884	Apr. 5	Nov. 29	1893	Apr. 4	Dec. 8
1876	Apr. 12	Nov. 29	1885	Apr. 9	Dec. 5	1894	Apr. 2	Nov. 30
1877	Apr. 12	Dec. 6	1886	Apr. 2	Dec. 4	1895	Apr. 8	Dec. 6
1878	Apr. 11	Dec. 7	1887	Apr. 11	Dec. 11	1896	Apr. 1	
1879	Apr. 21	Dec. 10	1888	Apr. 9	Dec. 7			

Average date of opening, April 7; average date of closing, December 5; average number of days closed, 123.

Authority: Mr. S. S. Smith, superintendent.

No. 158.—DELAWARE AND RARITAN CANAL, TRENTON, N. J.

[40° 13′ latitude north. 74° 45′ longitude west.]

Year.	Opened.	Closed.	Year.	Opened.	Closed.	Year.	Opened.	Closed.
1834	a Aug. 20	Dec. 15	1856	Mar. 28	Dec. 25	1877	Mar. 19	Dec. 22
1835	Mar. 16	.....	1857	Mar. 12	.....	1878	Mar. 18	Dec. 21
1836	Apr. 18	.....	1858	.....	Jan. 10	1879	Mar. 17	Dec. 20
1837	Apr. 20	.....	1858	.....	Dec. 25	1880	Mar. 15	Dec. 18
1838	Apr. 10	.....	1859	Mar. 15	Dec. 24	1881	Mar. 21	Dec. 20
1839	Mar. 15	.....	1860	Mar. 20	Dec. 24	1882	Mar. 6	Dec. 20
1840	.....	.....	1861	Mar. 21	Dec. 20	1883	Mar. 12	Dec. 20
1841	Apr. 5	.....	1862	Mar. 20	Dec. 20	1884	Mar. 10	Dec. 20
1842	Mar. 28	.....	1863	Mar. 10	Dec. 25	1885	Mar. 16	Dec. 19
1843	May 1	.....	1864	Mar. 8	Dec. 17	1886	Mar. 15	Dec. 20
1844	.....	.....	1865	Mar. 14	Dec. 23	1887	Mar. 14	Dec. 19
1845	Mar. 18	.....	1866	Mar. 15	Dec. 18	1888	Mar. 12	Dec. 20
1846	Apr. 15	.....	1867	Mar. 18	Dec. 20	1889	Mar. 11	Dec. 20
1847	Mar. 5	.....	1868	Mar. 23	Dec. 19	1890	Mar. 27	Dec. 23
1848	Mar. 20	Dec. 25	1869	Mar. 10	Dec. 25	1891	Mar. 9	Dec. 19
1849	Mar. 15	Dec. 20	1870	Mar. 10	Dec. 24	1892	Mar. 7	Dec. 19
1850	Mar. 11	Dec. 28	1871	Mar. 13	Dec. 15	1893	Mar. 13	Dec. 20
1851	Mar. 14	Dec. 20	1872	Mar. 15	Dec. 15	1894	Mar. 6	Dec. 20
1852	Mar. 15	Dec. 24	1873	Mar. 17	Dec. 20	1895	Mar. 7	Dec. 20
1853	Apr. 4	.....	1874	Mar. 16	Dec. 19	1896	Mar. 9	.....
1854	Mar. 1	.....	1875	Mar. 22	Dec. 24			
1855	Feb. 15	Dec. 25	1876	Mar. 20	Dec. 20			

a Canal formally opened.

Average date of opening, March 15; average date of closing, December 23; average number of days closed, 82.

Authorities: Mr. W. H. Dunn, superintendent, and United States Weather Bureau.

No. 159.—DES MOINES RAPIDS CANAL, MONTROSE, IOWA.

[40° 61′ latitude north. Altitude, 500 feet. 91° 25′ longitude west.]

Year.	Opened.	Closed.	Year.	Opened.	Closed.	Year.	Opened.	Closed.
1877	Aug. 22	Dec. 10	1884	Apr. 1	Nov. 23	1891	Apr. 1	Nov. 21
1878	Mar. 8	Nov. 28	1885	Apr. 1	Nov. 24	1892	Apr. 1	Nov. 23
1879	Mar. 17	Dec. 6	1886	Apr. 1	Nov. 21	1893	Apr. 1	Nov. 15
1880	Mar. 8	Nov. 19	1887	Mar. 28	Nov. 23	1894	Mar. 21	Nov. 1
1881	Apr. 16	Oct. 17	1888	Mar. 29	Nov. 22	1895	Mar. 15	Nov. 22
1882	Mar. 6	Nov. 25	1889	Mar. 18	Nov. 23	1896	Mar. 1	.....
1883	Apr. 13	Dec. 6	1890	Apr. 1	Nov. 20			

Average date of opening, March 24; average date of closing, November 21; average number of days closed, 123.

Authorities: Report of Secretary of War, United States Engineers, 1889–1895; Mr. Montgomery Meigs, United States civil engineer in charge.

No. 160.—ERIE CANAL.

Year.	Opened.	Closed.	Year.	Opened.	Closed.	Year.	Opened.	Closed.
1824	Apr. 4	Dec. 4	1849	May 1	Dec. 5	1874	May 5	Dec. 5
1825	Apr. 12	Dec. 5	1850	Apr. 22	Dec. 11	1875	Apr. 17	Nov. 30
1826	Apr. 20	Dec. 18	1851	Apr. 15	Dec. 5	1876	May 4	Dec. 1
1827	Apr. 22	Dec. 18	1852	Apr. 20	Dec. 16	1877	May 8	Dec. 7
1828	Mar. 27	Dec. 20	1853	Apr. 20	Dec. 20	1878	Apr. 15	Dec. 7
1829	May 2	Dec. 17	1854	May 1	Dec. 3	1879	May 8	Dec. 6
1830	Apr. 20	Dec. 17	1855	May 1	Dec. 10	1880	Apr. 19	Nov. 22
1831	Apr. 16	Dec. 1	1856	May 5	Dec. 4	1881	May 17	Dec. 6
1832	Apr. 25	Dec. 21	1857	May 6	Dec. 15	1882	Apr. 12	Nov. 28
1833	Apr. 10	Dec. 12	1858	Apr. 28	Dec. 8	1883	May 7	Dec. 1
1834	Apr. 17	Dec. 12	1859	Apr. 15	Dec. 12	1884	May 7	Dec. 1
1835	Apr. 15	Nov. 30	1860	Apr. 25	Nov. 12	1885	May 11	Dec. 1
1836	Apr. 25	Nov. 26	1861	May 1	Dec. 10	1886	May 1	Dec. 1
1837	Apr. 20	Dec. 9	1862	May 1	Dec. 10	1887	May 7	Dec. 1
1838	Apr. 12	Nov. 25	1863	May 1	Dec. 9	1888	May 10	Dec. 3
1839	Apr. 20	Dec. 16	1864	Apr. 30	Dec. 8	1889	May 1	Dec. 1
1840	Apr. 20	Dec. 3	1865	May 1	Dec. 12	1890	Apr. 28	Dec. 1
1841	Apr. 24	Nov. 30	1866	May 1	Dec. 12	1891	May 5	Dec. 5
1842	Apr. 20	Nov. 28	1867	May 6	Dec. 20	1892	May 1	Dec. 5
1843	May 1	Nov. 30	1868	May 4	Dec. 7	1893	May 3	Nov. 30
1844	Apr. 18	Nov. 26	1869	May 6	Dec. 10	1894	May 1	Dec. 1
1845	Apr. 15	Nov. 29	1870	May 10	Dec. 8	1895	May 3	Dec. 5
1846	Apr. 16	Nov. 25	1871	Apr. 24	Dec. 1	1896	May 1	.....
1847	May 1	Nov. 30	1872	May 13	Dec. 1			
1848	May 1	Dec. 9	1873	May 15	Dec. 5			

Average date of opening, April 27; average date of closing, December 5; average number of days closed, 143.

Authorities: General Report Public Works, Canada, 1867-1882; Internal Commerce of United States, 1885; Marine Review, 1896.

No. 161.—FARRANS POINT CANAL.

Year.	Opened.	Closed.	Year.	Opened.	Closed.	Year.	Opened.	Closed.
1848	Apr. 13	Dec. 6	1865	Apr. 29	Dec. 13	1882	Apr. 24	Dec. 11
1849	Apr. 9	Dec. 15	1866	May 1	Dec. 11	1883	May 1	Dec. 16
1850	Apr. 27	Dec. 10	1867	Apr. 30	Dec. 6	1884	May 1	Dec. 17
1851	Apr. 25	Nov. 25	1868	Apr. 27	Dec. 5	1885	May 4	Dec. 6
1852	Apr. 13	Nov. 24	1869	May 1	Dec. 3	1886	Apr. 29	Dec. 4
1853	May 1	Dec. 1	1870	Apr. 23	Dec. 10	1887	May 30	Dec. 5
1854	May 3	Dec. 8	1871	Apr. 21	Dec. 6	1888	May 2	Dec. 10
1855	Apr. 20	Dec. 15	1872	May 1	Dec. 7	1889	Apr. 22	Dec. 9
1856	Apr. 28	Dec. 6	1873	May 1	Dec. 2	1890	Apr. 22	Dec. 4
1857	May 1	Dec. 12	1874	May 1	Dec. 5	1891	Apr. 21	Dec. 12
1858	Apr. 25	Dec. 11	1875	May 1	Dec. 2	1892	Apr. 20	Dec. 13
1859	Apr. 30	Dec. 5	1876	May 1	Dec. 5	1893	Apr. 27	Dec. 13
1860	Apr. 21	Dec. 10	1877	May 1	Dec. 7	1894	Apr. 23	Dec. 10
1861	Apr. 24	Dec. 10	1878	Apr. 29	Dec. 12	1895	Apr. 23	Dec. 10
1862	Apr. 29	Nov. 30	1879	Apr. 28	Dec. 9	1896	Apr. 22	.....
1863	May 1	Dec. 7	1880	Apr. 20	Dec. 11			
1864	Apr. 26	Dec. 10	1881	Apr. 27	Dec. 10			

Average date of opening, April 27; average date of closing, December 7; average number of days closed, 141.

Authorities: General Report Public Works, Canada, 1867-1882; Annual Report of the Department of Railways and Canals, Dominion of Canada, 1883-1895; Department of Public Works, Dominion of Canada, 1896.

No. 162.—GRENVILLE CANAL.

Year.	Opened.	Closed.	Year.	Opened.	Closed.	Year.	Opened.	Closed.
1859	Apr. 29	Nov. 28	1872	May 23	Dec. 18	1885	May 7	Nov. 30
1860	Apr. 28	Nov. 29	1873	May 1	Nov. 18	1886	May 1	Nov. 30
1861	May 3	Nov. 29	1874	May 6	Nov. 25	1887	May 2	Nov. 30
1862	May 3	Nov. 30	1875	May 7	Nov. 20	1888	May 2	Dec. 2
1863	May 1	Dec. 2	1876	May 8	Nov. 30	1889	Apr. 26	Nov. 30
1864	May 2	Nov. 30	1877	May 1	Dec. 5	1890	Apr. 26	Nov. 29
1865	May 1	Nov. 30	1878	May 3	Sept. 6	1891	Apr. 23	Nov. 28
1866	May 3	Nov. 30	1879	May 5	Nov. 24	1892	Apr. 30	Nov. 30
1867	May 7	Nov. 30	1880	Apr. 24	Nov. 23	1893	May 1	Nov. 30
1868	May 2	Nov. 30	1881	May 2	Nov. 26	1894	Apr. 23	Nov. 30
1869	May 3	Nov. 26	1882	May 1	Nov. 24	1895	Apr. 29	Nov. 30
1870	Apr. 27	Dec. 6	1883	May 1	Nov. 27	1896	Apr. 27	.....
1871	May 1	Nov. 27	1884	Apr. 28	Nov. 26			

Average date of opening, May 1; average date of closing, November 28; average number of days closed, 154.

Authorities: General Report Public Works, Canada, 1867-1882; Annual Reports Department of Railways and Canals, Dominion of Canada, 1883-1896; Department of Public Works, Dominion of Canada, 1896.

No. 163.—ILLINOIS AND MICHIGAN CANAL, CHICAGO.

Year.	Opened.	Closed.	Year.	Opened.	Closed.	Year.	Opened.	Closed.
1850	Mar. 22	Dec. 6	1866	Apr. 11	Oct. 31	1882	Mar. 13	Nov. 30
1851	Mar. 15	Dec. 8	1867	Apr. 10	Nov. 15	1883	Apr. 2	Nov. 25
1852	Mar. 29	Dec. 8	1868	Apr. 4	Oct. 31	1884	Apr. 7	Dec. 1
1853	Mar. 14	Dec. 12	1869	Apr. 7	Nov. 15	1885	Apr. 15	Nov. 25
1854	Mar. 15	Dec. 2	1870	Apr. 7	Oct. 8	1886	Apr. 1	Nov. 25
1855	Apr. 3	Dec. 12	1871	Apr. 6	Nov. 25	1887	Apr. 1	Nov. 19
1856	Apr. 8	Dec. 4	1872	Apr. 1	Dec. 1	1888	Apr. 10	Nov. 15
1857	May 1	Nov. 30	1873	Apr. 10	Nov. 20	1889	Mar. 25	Nov. 15
1858	Apr. 1	Dec. 1	1874	Mar. 30	Nov. 20	1890	Apr. 1	Nov. 21
1859	Mar. 16	Dec. 3	1875	Apr. 15	Nov. 28	1891	Apr. 1	Nov. 22
1860	Mar. 8	Nov. 26	1876	Mar. 25	Nov. 18	1892	Apr. 1	Nov. 15
1861	Mar. 4	Nov. 28	1877	Apr. 16	Dec. 1	1893	Apr. 1	Nov. 15
1862	Apr. 1	.....	1878	Mar. 20	Dec. 1	1894	Apr. 1	Nov. 15
1863	Mar. 4	Dec. 1	1879	Mar. 29	Nov. 20	1895	Apr. 1	Nov. 15
1864	Mar. 10	Dec. 1	1880	Mar. 22	Nov. 18	1896	Apr. 1	.....
1865	Apr. 10	Nov. 15	1881	Apr. 25	Nov. 26			

Average date of opening, April 1; average date of closing, November 24; average number of days closed, 128.

Authority: Annual Report of the Trade and Commerce of Chicago, 1895.

No. 164.—LACHINE CANAL.

Year.	Opened.	Closed.	Year.	Opened.	Closed.	Year.	Opened.	Closed.
1835	.....	Nov. 22	1856	May 1	Dec. 3	1877	May 7	Dec. 4
1836	May 1	Nov. 25	1857	May 4	Nov. 27	1878	May 6	Dec. 5
1837	Apr. 26	Nov. 24	1858	Apr. 25	Dec. 1	1879	May 4	Dec. 4
1838	Apr. 23	Nov. 23	1859	Apr. 21	Nov. 30	1880	Apr. 25	Nov. 27
1839	Apr. 11	Nov. 23	1860	Apr. 20	Dec. 5	1881	May 1	Dec. 1
1840	Apr. 21	Nov. 23	1861	Apr. 24	Dec. 4	1882	Apr. 25	Dec. 1
1841	May 1	Nov. 25	1862	May 4	Dec. 6	1883	May 1	Dec. 1
1842	May 2	Nov. 26	1863	May 4	Dec. 10	1884	May 5	Nov. 30
1843	May 4	Nov. 28	1864	Apr. 25	Dec. 10	1885	May 4	Nov. 30
1844	Apr. 23	Nov. 17	1865	May 1	Dec. 12	1886	May 3	Nov. 30
1845	May 5	Nov. 28	1866	May 2	Dec. 13	1887	May 5	Nov. 30
1846	May 6	Dec. 9	1867	May 1	Dec. 2	1888	May 1	Dec. 2
1847	May 5	Dec. 13	1868	Apr. 27	Dec. 5	1889	Apr. 21	Nov. 30
1848	Apr. 24	Dec. 11	1869	May 3	Dec. 7	1890	Apr. 23	Nov. 29
1849	Apr. 21	Dec. 10	1870	Apr. 29	Dec. 10	1891	Apr. 28	Nov. 30
1850	Apr. 22	Dec. 7	1871	Apr. 24	Dec. 6	1892	May 1	Nov. 30
1851	Apr. 22	Dec. 10	1872	May 1	Dec. 7	1893	May 4	Nov. 30
1852	May 7	Dec. 16	1873	May 5	Nov. 29	1894	Apr. 23	Nov. 30
1853	May 20	Dec. 2	1874	Apr. 29	Dec. 4	1895	Apr. 30	Nov. 30
1854	May 13	Dec. 2	1875	May 1	Nov. 30	1896	May 3	.....
1855	May 1	Nov. 28	1876	May 1	Dec. 2			

Average date of opening, April 30; average date of closing, December 2; average number of days closed, 149.

Authorities: General Report of Public Works, Canada, 1867-1882; Annual Reports of the Department of Railways and Canals, Dominion of Canada, 1883-1895; Department of Public Works, Dominion of Canada, 1896.

No. 165.—HOUGHTON, MICH.

[47° 04′ latitude north. Altitude, 600.69 feet. 88° 17′ longitude west.]

Year.	Opened.	Closed.	Year.	Opened.	Closed.	Year.	Opened.	Closed.
1882	Apr. 30	Dec. 1	1887	May 5	Nov. 27	1892	Apr. 26	Nov. 30
1883	Apr. 28	Nov. 25	1888	May 15	Nov. 16	1893	May 9	Dec. 1
1884	May. 8	Nov. 28	1889	Apr. 25	Nov. 20	1894	Apr. 22	Nov. 28
1885	May. 11	Nov. 26	1890	Apr. 28	Nov. 25	1895	Apr. 22	Dec. 2
1886	Apr. 28	Nov. 26	1891	May 1	Nov. 29	1896	Apr. 22	.....

Average date of opening, May 1; average date of closing, November 27; average number of days closed, 155.

Authorities: Mr. G. A. Marr, C. E., assistant engineer Portage Lake Ship Canals; Mr. J. C. Thompson, agent Anchor and Western Steamship Lines.

NOTE.—This data applies to the Portage Lake Ship Canals.

No. 166.—RAPIDE PLAT CANAL.

Year.	Opened.	Closed.	Year.	Opened.	Closed.	Year.	Opened.	Closed.
1848	Apr. 13	Dec. 6	1865	Apr. 29	Dec. 13	1882	Apr. 24	Dec. 11
1849	Apr. 9	Dec. 15	1866	May 1	Dec. 11	1883	May 1	Dec. 16
1850	Apr. 27	Dec. 10	1867	Apr. 30	Dec. 6	1884	May 1	Dec. 17
1851	Apr. 25	Nov. 25	1868	Apr. 27	Dec. 5	1885	May 4	Dec. 6
1852	Apr. 13	Nov. 24	1869	May 1	Dec. 3	1886	Apr. 29	Dec. 4
1853	May 1	Dec. 1	1870	Apr. 23	Dec. 10	1887	May 30	Dec. 5
1854	May 3	Dec. 8	1871	Apr. 21	Dec. 6	1888	May 2	Dec. 10
1855	Apr. 20	Dec. 15	1872	May 1	Dec. 7	1889	Apr. 22	Dec. 9
1856	Apr. 28	Dec. 6	1873	May 1	Dec. 2	1890	Apr. 22	Dec. 4
1857	May 1	Dec. 12	1874	May 1	Dec. 5	1891	Apr. 21	Dec. 12
1858	Apr. 25	Dec. 11	1875	May 1	Dec. 2	1892	Apr. 20	Dec. 13
1859	Apr. 30	Dec. 5	1876	May 1	Dec. 5	1893	Apr. 27	Dec. 13
1860	Apr. 21	Dec. 10	1877	May 1	Dec. 5	1894	Apr. 23	Dec. 10
1861	Apr. 24	Dec. 10	1878	Apr. 29	Dec. 12	1895	Apr. 23	Dec. 10
1862	Apr. 29	Nov. 30	1879	Apr. 28	Dec. 9	1896	Apr. 22	.....
1863	May 1	Dec. 7	1880	Apr. 20	Dec. 11			
1864	Apr. 26	Dec. 10	1881	Apr. 27	Dec. 10			

Average date of opening, April 27; average date of closing, December 7; average number of days closed, 141.

Authorities: General Report Public Works, Canada, 1867-1882; Annual Report of the Department of Railways and Canals, Dominion of Canada, 1883-1895; Department of Public Works, Dominion of Canada, 1896.

No. 167.—RIDEAU CANAL, JONES FALLS, ONTARIO.

Year.	Opened.	Closed.	Year.	Opened.	Closed.	Year.	Opened.	Closed.
1832	July 30	Nov. 14	1854	Apr. 27	Nov. 29	1876	May 4	Nov. 25
1833	June 7	Nov. 7	1855	May 2	Nov. 28	1877	May 2	Nov. 16
1834	Apr. 28	Nov. 13	1856	May 1	Nov. 28	1878	May 1	Nov. 29
1835	Apr. 23	Nov. 23	1857	Apr. 22	Nov. 21	1879	May 5	Nov. 21
1836	May 6	Nov. 16	1858	May 1	Nov. 19	1880	Apr. 28	Nov. 17
1837	Apr. 30	Nov. 23	1859	Apr. 20	Nov. 23	1881	May 2	Nov. 21
1838	Apr. 25	Nov. 24	1860	May 1	Nov. 25	1882	May 2	Nov. 20
1839	Apr. 29	Nov. 24	1861	May 2	Nov. 23	1883	May 4	Nov. 25
1840	Apr. 23	Nov. 22	1862	May 1	Nov. 19	1884	.....	.....
1841	Apr. 30	Nov. 24	1863	May 4	Nov. 26	1885	.....	.....
1842	Apr. 22	Nov. 26	1864	May 1	Nov. 29	1886	.....	.....
1843	Apr. 29	Nov. 29	1865	Apr. 24	Nov. 30	1887	.....	.....
1844	Apr. 22	Nov. 23	1866	May 3	Dec. 2	1888	.....	.....
1845	Apr. 26	Nov. 28	1867	May 1	Nov. 20	1889	.....	.....
1846	Apr. 19	Nov. 30	1868	May 1	Nov. 22	1890	.....	.....
1847	May 1	Nov. 29	1869	May 1	Nov. 15	1891	.....	.....
1848	Apr. 20	Nov. 30	1870	May 1	Nov. 28	1892	.....	.....
1849	Apr. 26	Nov. 30	1871	Apr. 20	Nov. 24	1893	.....	.....
1850	May 2	Nov. 30	1872	May 1	Nov. 27	1894	.....	.....
1851	Apr. 26	Nov. 12	1873	May 1	Nov. 13	1895	Apr. 28	.....
1852	May 1	Nov. 23	1874	May 1	Nov. 20	1896	.....	.....
1853	Apr. 27	Nov. 27	1875	May 4	Nov. 15			

Average date of opening, April 29; average date of closing, November 22; average number of days closed, 158.

Authority: General Report Public Works, Canada, 1867-1882.

No. 168.—RIDEAU CANAL, KINGSTON, ONTARIO.

Year.	Opened.	Closed.	Year.	Opened.	Closed.	Year.	Opened.	Closed.
1848	May 1	Nov. 30	1865	Apr. 25	Dec. 6	1882	May 1	Dec. 19
1849	May 2	Nov. 30	1866	May 1	Dec. 4	1883	May 7	Nov. 28
1850	May 1	Dec. 1	1867	May 1	Nov. 30	1884	May 5	Nov. 18
1851	Apr. 25	Nov. 30	1868	May 1	Nov. 29	1885	May 11	Nov. 28
1852	May 1	Nov. 30	1869	May 1	Nov. 14	1886	May 7	Nov. 30
1853	May 1	Nov. 30	1870	Apr. 28	Nov. 27	1887	May 2	Nov. 25
1854	May 1	Nov. 30	1871	Apr. 21	Nov. 26	1888	May 3	Nov. 21
1855	May 1	Nov. 28	1872	May 1	Nov. 26	1889	Apr. 29	Nov. 22
1856	May 1	Nov. 28	1873	May 1	Nov. 21	1890	May 2	Nov. 26
1857	Apr. 23	Nov. 23	1874	May 1	Nov. 20	1891	May 1	Nov. 30
1858	May 1	Nov. 22	1875	May 3	Nov. 18	1892	May 1	Nov. 30
1859	Apr. 16	Nov. 30	1876	May 5	Nov. 27	1893	May 1	Nov. 23
1860	May 1	Nov. 29	1877	Apr. 30	Nov. 30	1894	Apr. 30	Nov. 19
1861	May 1	Nov. 25	1878	May 1	Nov. 30	1895	Apr. 30	Nov. 29
1862	May 1	Nov. 30	1879	May 5	Nov. 21	1896	May 2	.....
1863	May 1	Nov. 30	1880	Apr. 27	Dec. 17			
1864	Apr. 27	Nov. 30	1881	May 2	Dec. 20			

Average date of opening, May 1; average date of closing, November 28; average number of days closed, 154.

Authorities: General Report Public Works, Canada, 1867–1882; Annual Reports Department of Railway and Canals, Dominion of Canada, 1883–1896; Department of Public Works, Dominion of Canada, 1896.

No. 169.—RIDEAU CANAL, OTTAWA, ONTARIO.

[45° 16′ latitude north. 75° 42′ longitude west.]

Year.	Opened.	Closed.	Year.	Opened.	Closed.	Year.	Opened.	Closed.
1832	May 29	Nov. 14	1854	May 1	Nov. 22	1876	May 6	Dec. 5
1833	May 8	Nov. 1	1855	Apr. 30	Nov. 25	1877	May 1	Dec. 3
1834	Apr. 17	Nov. 14	1856	May 1	Nov. 27	1878	May 1	Dec. 4
1835	Apr. 27	Nov. 16	1857	May 2	Nov. 25	1879	May 5	Nov. 23
1836	May 10	Nov. 15	1858	May 2	Nov. 21	1880	Apr. 28	Nov. 24
1837	May 2	Dec. 1	1859	Apr. 27	Nov. 19	1881	May 2	Nov. 23
1838	May 2	Nov. 19	1860	May 2	Nov. 28	1882	May 1	Nov. 27
1839	Apr. 22	Nov. 23	1861	Apr. 30	Nov. 26	1883	May 3	Nov. 27
1840	Apr. 22	Nov. 24	1862	May 1	Nov. 27	1884	May 1	Nov. 24
1841	Apr. 28	Nov. 24	1863	May 1	Nov. 28	1885	May 8	Nov. 30
1842	Apr. 23	Nov. 25	1864	May 1	Dec. 2	1886	May 3	Nov. 29
1843	May 2	Nov. 27	1865	Apr. 27	Dec. 4	1887	May 3	Nov. 25
1844	Apr. 24	Nov. 23	1866	May 1	Dec. 6	1888	May 3	Nov. 22
1845	Apr. 26	Nov. 28	1867	May 1	Dec. 5	1889	Apr. 29	Nov. 28
1846	Apr. 21	Dec. 2	1868	Apr. 30	Nov. 30	1890	May 5	Nov. 29
1847	May 4	Nov. 28	1869	May 6	Nov. 27	1891	Apr. 28	Nov. 28
1848	Apr. 17	Nov. 27	1870	May 2	Dec. 5	1892	May 2	Nov. 30
1849	May 16	Nov. 30	1871	Apr. 22	Nov. 29	1893	Apr. 29	Nov. 30
1850	May 3	Dec. 2	1872	May 3	Nov. 30	1894	May 1	Nov. 28
1851	Apr. 28	Nov. 24	1873	May 5	Nov. 19	1895	Apr. 27	Nov. 30
1852	May 4	Nov. 24	1874	May 5	Nov. 26	1896	May 1	.....
1853	Apr. 27	Nov. 24	1875	May 5	Nov. 22			

Average date of opening, April 30; average date of closing, November 25; average number of days closed, 156.

Authorities: General Report Public Works, Canada, 1867–1882; Annual Reports Department of Railways and Canals, Dominion of Canada, 1883–1896; Department of Public Works, Dominion of Canada, 1896.

No. 170.—STE. ANNE'S LOCK AND DAM.

Year	Opened.	Closed.	Year.	Opened.	Closed.	Year.	Opened.	Closed.
1843	June 26	Nov. 27	1861	Apr. 27	Dec. 2	1879	Apr. 21	Dec. 3
1844	Apr. 28	Nov. 25	1862	Apr. 29	Dec. 2	1880	Apr. 24	Nov. 24
1845	Apr. 24	Nov. 28	1863	Apr. 28	Dec. 5	1881	Apr. 18	Nov. 20
1846	Apr. 11	Nov. 29	1864	Apr. 23	Dec. 1	1882	Apr. 11	Nov. 30
1847	May 5	Nov. 29	1865	Apr. 12	Dec. 5	1883	Apr. 30	Nov. 26
1848	Apr. 16	Nov. 30	1866	Apr. 26	Dec. 6	1884	Apr. 26	Nov. 24
1849	Apr. 20	Dec. 6	1867	May 1	Dec. 3	1885	May 7	Nov. 26
1850	Apr. 29	Dec. 5	1868	Apr. 18	Nov. 27	1886	Apr. 27	Nov. 27
1851	Apr. 17	Nov. 24	1869	Apr. 29	Nov. 21	1887	May 4	Nov. 28
1852	Apr. 30	Dec. 15	1870	Apr. 19	Nov. 30	1888	May 2	Nov. 22
1853	Apr. 24	Nov. 28	1871	Apr. 13	Nov. 27	1889	May 19	Nov. 29
1854	Apr. 29	Dec. 2	1872	Apr. 29	Nov. 29	1890	Apr. 24	Nov. 25
1855	Apr. 30	Nov. 27	1873	Apr. 24	Nov. 20	1891	Apr. 25	Nov. 26
1856	Apr. 25	Dec. 1	1874	May 4	Nov. 26	1892	Apr. 27	Nov. 28
1857	Apr. 25	Dec. 4	1875	May 3	Nov. 22	1893	Apr. 29	Nov. 27
1858	Apr. 19	Nov. 29	1876	May 1	Nov. 29	1894	Apr. 21	Nov. 25
1859	Apr. 18	Nov. 28	1877	Apr. 21	Dec. 4	1895	Apr. 25	Nov. 29
1860	Apr. 21	Dec. 2	1878	Apr. 15	Dec. 6	1896	Apr. 26	.....

Average date of opening, April 25; average date of closing, November 29; average number of days closed, 147.

Authorities: General Report Public Works, Canada, 1867-1882; Annual Reports Department of Railways and Canals, Dominion of Canada, 1883-1896; Department of Public Works, Dominion of Canada, 1896.

No. 171.—SAULT STE. MARIE CANAL, MICHIGAN.

[46° 28′ latitude north. Sault Ste. Marie altitude, 600.05 feet. 84° 22′ longitude west.]

Year.	Opened.	Closed.	Year.	Opened.	Closed.	Year.	Opened.	Closed.
1855	.....	Nov. 23	1869	May 4	Nov. 29	1883	May 2	Dec. 11
1856	May 4	Nov. 28	1870	Apr. 29	Dec. 1	1884	Apr. 23	Dec. 10
1857	May 9	Nov. 30	1871	May 8	Nov. 29	1885	May 6	Dec. 2
1858	Apr. 18	Nov. 20	1872	May 11	Nov. 26	1886	Apr. 25	Dec. 4
1859	May 3	Nov. 28	1873	May 5	Nov. 28	1887	May 1	Dec. 2
1860	May 11	Nov. 26	1874	May 12	Dec. 2	1888	May 7	Dec. 4
1861	May 3	Nov. 14	1875	May 12	Dec. 2	1889	Apr. 15	Dec. 4
1862	Apr. 27	Nov. 17	1876	May 8	Nov. 26	1890	Apr. 20	Dec. 3
1863	Apr. 28	Nov. 24	1877	May 2	Nov. 30	1891	Apr. 17	Dec. 8
1864	May 2	Dec. 4	1878	Apr. 8	Dec. 3	1892	Apr. 18	Dec. 6
1865	May 1	Dec. 3	1879	May 2	Dec. 3	1893	Apr. 29	Dec. 6
1866	May 5	Dec. 3	1880	Apr. 28	Nov. 15	1894	Apr. 17	Dec. 6
1867	May 4	Dec. 3	1881	May 7	Dec. 5	1895	Apr. 25	Dec. 11
1868	May 2	Dec. 3	1882	Apr. 21	Dec. 3	1896	Apr. 16	.....

Average date of opening, April 25; average date of closing, December 3; average number of days closed, 143.

Authorities: Monthly Weather Review, Reports of the United States Chief Signal Officer; Marine Review, 1896.

No. 172.—ST. OURS LOCK.

Year.	Opened.	Closed.	Year.	Opened.	Closed.	Year.	Opened.	Closed.
1850	Apr. 14	Dec. 6	1866	Apr. 9	Dec. 12	1882	Apr. 13	Nov. 28
1851	Apr. 9	Nov. 22	1867	Apr. 26	Dec. 2	1883	Apr. 19	Nov. 29
1852	Apr. 10	Dec. 13	1868	Mar. 30	Dec. 2	1884	Apr. 7	Nov. 30
1853	Apr. 13	Dec. 4	1869	Apr. 28	Dec. 1	1885	May 4	Nov. 28
1854	Apr. 19	Dec. 4	1870	Apr. 12	Dec. 5	1886	Apr. 15	Nov. 30
1855	Apr. 23	Nov. 30	1871	Mar. 20	Nov. 28	1887	May 2	Nov. 25
1856	Apr. 18	Dec. 2	1872	Apr. 20	Dec. 1	1888	Apr. 19	Nov. 24
1857	Apr. 17	Dec. 4	1873	May 1	Nov. 16	1889	Apr. 19	Nov. 28
1858	Apr. 9	Nov. 19	1874	Apr. 16	Nov. 25	1890	Apr. 28	Nov. 28
1859	Apr. 5	Dec. 3	1875	Apr. 16	Nov. 22	1891	May 8	Nov. 30
1860	Apr. 4	Dec. 5	1876	Apr. 19	Nov. 30	1892	Apr. 11	Nov. 30
1861	Apr. 16	Dec. 3	1877	Apr. 10	Dec. 5	1893	Apr. 18	Nov. 26
1862	Apr. 25	Dec. 2	1878	Apr. 1	Dec. 12	1894	Apr. 2	Nov. 26
1863	Apr. 29	Dec. 3	1879	Apr. 23	Nov. 24	1895	Apr. 15	Nov. 29
1864	Apr. 7	Dec. 9	1880	Apr. 7	Nov. 22	1896	Apr. 29	.....
1865	Apr. 16	Dec. 9	1881	Apr. 1	Nov. 25			

Average date of opening, April 16; average date of closing, November 30; average number of days closed, 137.

Authorities: General Report Public Works, Canada, 1867-1882; Annual Reports Department of Railways and Canals, Dominion of Canada, 1883-1896; Department of Public Works, Dominion of Canada, 1896.

No. 173.—ST. PETERS CANAL.

Year.	Opened.	Closed.	Year.	Opened.	Closed.	Year.	Opened.	Closed.
1870	.....	.....	1882	May 5	.....	1890	Apr. 21	Dec. 24
1871	.....	Jan. 19	1883	.....	Jan. 1	1891	Jan. 20	.....
1871	Apr. 15	.....	1883	Apr. 16	.....	1891	Apr. 22	.....
1872	.....	Dec. 16	1884	.....	Jan. 2	1892	.....	Jan. 20
1873	Apr. 15	Dec. 10	1884	Apr. 20	.....	1892	Apr. 1	.....
1874	May 5	Dec. 15	1885	.....	Jan. 2	1893	.....	Jan. 9
1875	May 10	Dec. 14	1885	May 1	Jan. 30	1893	Apr. 24	.....
1876	May 3.	Closed	1886	May 15	Nov. 27	1894	.....	Jan. 6
1877	since June, 1876.		1887	Apr. 27	.....	1894	Apr. 28	Dec. 15a
1878	Closed since		1888	.....	Jan. 7	1895	Closed for repairs.	
1879	June,'76	Open.	1888	Apr. 28	.....	1896	Mar. 30	.....
1880	Open.	Open.	1889	.....	Jan. 6			
1881	Open.	Dec. 31	1889	Mar. 23	Nov. 23			

a For repairs.

Average date of opening, April 22; average date of closing, December 31; average number of days closed, 112.

Authorities: Annual Reports Department of Railways and Canals, Dominion of Canada, 1883–1896; Department of Public Works, Dominion of Canada, 1896.

No. 174.—THE GALOPS CANAL.

Year.	Opened.	Closed	Year.	Opened.	Closed.	Year.	Opened.	Closed.
1848	Apr. 13	Dec. 6	1865	Apr. 29	Dec. 13	1882	Apr. 24	Dec. 11
1849	Apr. 9	Dec. 15	1866	May 1	Dec. 11	1883	May 1	Dec. 16
1850	Apr. 27	Dec. 10	1867	Apr. 30	Dec. 6	1884	May 1	Dec. 17
1851	Apr. 25	Nov. 25	1868	Apr. 27	Dec. 5	1885	May 4	Dec. 6
1852	Apr. 13	Nov. 24	1869	May 1	Dec. 3	1886	Apr. 29	Dec. 4
1853	May 1	Dec. 1	1870	Apr. 23	Dec. 10	1887	May 30	Dec. 5
1854	May 3	Dec. 8	1871	Apr. 21	Dec. 6	1888	May 2	Dec. 10
1855	Apr. 20	Dec. 15	1872	May 1	Dec. 7	1889	Apr. 22	Dec. 9
1856	Apr. 28	Dec. 6	1873	May 1	Dec. 2	1890	Apr. 22	Dec. 4
1857	May 1	Dec. 12	1874	May 1	Dec. 5	1891	Apr. 21	Dec. 12
1858	Apr. 25	Dec. 11	1875	May 1	Dec. 2	1892	Apr. 20	Dec. 13
1859	Apr. 30	Dec. 5	1876	May 1	Dec. 5	1893	Apr. 27	Dec. 13
1860	Apr. 21	Dec. 10	1877	May 1	Dec. 5	1894	Apr. 23	Dec. 10
1861	Apr. 24	Dec. 10	1878	Apr. 29	Dec. 12	1895	Apr. 23	Dec. 10
1862	Apr. 29	Nov. 30	1879	Apr. 28	Dec. 9	1896	Apr. 22	.....
1863	May 1	Dec. 7	1880	June 30	Dec. 11			
1864	Apr. 26	Dec. 10	1881	Apr. 27	Dec. 10			

Average date of opening, April 27; average date of closing, December 7; average number of days closed, 141.

Authorities: General Report Public Works, Canada, 1867–1882; Annual Report of the Department of Railways and Canals, Dominion of Canada, 1883–1895; Department of Public Works, Dominion of Canada, 1896.

No. 175.—TRENT RIVER, TRENTON, ONTARIO.

[Altitude, 300 feet.]

Year.	Opened.	Closed.	Year.	Opened.	Closed.	Year.	Opened.	Closed.
1867	.....	Nov. 15	1877	Apr. 26	Dec. 25	1887	Mar. 27	Nov. 25
1868	May 1	Nov. 14	1878	May 1	Nov. 25	1888	Apr. 20	Nov. 22
1869	May 10	Dec. 2	1879	Apr. 29	Dec. 8	1889	Apr. 17	Nov. 23
1870	May 9	Nov. 24	1880	Apr. 7	Nov. 10	1890	Apr. 21	Nov. 24
1871	Apr. 10	Nov. 10	1881	Apr. 26	Nov. 25	1891	Apr. 20	Nov. 20
1872	Apr. 29	Nov. 11	1882	Mar. 15	Nov. 18	1892	Apr. 21	Nov. 26
1873	Apr. 16	Nov. 24	1883	Apr. 28	Nov. 28	1893	Apr. 10	Nov. 27
1874	Apr. 15	Nov. 5	1884	Mar. 26	Nov. 12	1894	Apr. 5	Nov. 23
1875	Apr. 16	Nov. 29	1885	Mar. 25	Nov. 26	1895	Apr. 26	Nov. 22
1876	Apr. 19	Nov. 24	1886	Apr. 1	Nov. 23	1896	Apr. 18	.....

Average date of opening, April 17; average date of closing, November 22; average number of days closed, 146.

Authorities: General report Public Works, Canada, 1867–1882; Mr. Thomas D. Belcher, superintending engineer; Annual reports Department of Public Works, Dominion of Canada, 1883–1896; Department of Public Works, Dominion of Canada, 1896.

No. 176.—WELLAND CANAL.

Year.	Opened.	Closed.	Year.	Opened.	Closed.	Year.	Opened.	Closed.
1831	Apr. 8		1853	Apr. 1	Dec. 17	1875	May 3	Dec. 15
1832	May 15		1854	Apr. 3	Dec. 4	1876	Apr. 17	Dec. 15
1833	May 20		1855	Apr. 16	Dec. 12	1877	Apr. 17	Dec. 5
1834	Apr. 10	Nov. 15	1856	Apr. 26	Dec. 13	1878	May 9	Dec. 14
1835	May 1		1857	May 1	Dec. 15	1879	May 5	Dec. 5
1836	Apr. 28		1858	Apr. 7	Dec. 1	1880	May 1	Nov. 30
1837	May 5		1859	Apr. 1	Dec. 8	1881	Apr. 29	Dec. 15
1838	Apr. 5		1860	Apr. 1	Dec. 6	1882	Apr. 20	Dec. 5
1839			1861	Apr. 8	Dec. 12	1883	Apr. 5	Dec. 16
1840	Apr. 2	Dec. 1	1862	Apr. 15	Dec. 15	1884	Apr. 15	Dec. 4
1841	May 4	Dec. 6	1863	Apr. 13	Dec. 13	1885	May 5	Dec. 9
1842			1864	Apr. 13	Dec. 11	1886	Apr. 19	Dec. 1
1843		Dec. 4	1865	Apr. 17	Dec. 15	1887	May 3	Dec. 10
1844	Apr. 1	Dec. 4	1866	Apr. 17	Dec. 11	1888	Apr. 23	Dec. 1
1845	May 7	Nov. 29	1867	Apr. 23	Dec. 7	1889	Apr. 16	Dec. 4
1846	Apr. 3	Dec. 15	1868	Apr. 15	Dec. 9	1890	Apr. 15	Dec. 10
1847	Apr. 14	Dec. 9	1869	Apr. 21	Dec. 10	1891	Apr. 20	Dec. 16
1848	Apr. 10	Dec. 19	1870	Apr. 20	Dec. 16	1892	Apr. 19	Dec. 12
1849	Apr. 3	Dec. 7	1871	Apr. 5	Dec. 9	1893	Apr. 24	Dec. 11
1850	Apr. 1	Dec. 12	1872	Apr. 22	Dec. 10	1894	Apr. 19	Dec. 11
1851	Mar. 25	Dec. 12	1873	Apr. 21	Dec. 15	1895	Apr. 20	Dec. 12
1852	Apr. 13	Dec. 14	1874	Apr. 9	Dec. 10	1896	Apr. 28	

Average date of opening, April 17; average date of closing, December 10; average number of days closed, 128.

Authorities: General Report Public Works, Canada, 1867-1882; Annual Report of the Department of Railways and Canals, Dominion of Canada, 1883-1895; Department of Public Works, Dominion of Canada, 1896.

M. No. 1.—BATHURST, NEW BRUNSWICK.

[47° 39′ latitude north. 65° 42′ longitude west.]

Year.	Opened.	Closed.	Year.	Opened.	Closed.	Year.	Opened.	Closed.
1867			1877			1887	Open.	Nov. 25
1868			1878	Apr. 30		1888	May 8	Dec. 5
1869			1879	Apr. 26		1889	Mar. 25	Dec. 4
1870			1880	Apr. 29		1890	May 3	Dec. 2
1871	Apr. 24	Nov. 6	1881	Apr. 26	Nov. 26	1891	Apr. 21	Dec. 18
1872			1882	May 15	Dec. 4	1892	Apr. 22	Dec. 14
1873			1883	May 3	Nov. 29	1893	May 1	Dec. 14
1874			1884	Apr. 28	Open.	1894	May 1	Nov. 29
1875	May 10		1885	Open.	Dec. 1	1895	Apr. 29	Nov. 25
1876	May 15	Dec. 5	1886	Apr. 27	Open.	1896	Apr. 28	

Average date of opening, April 27; average date of closing, December 22; average number of days closed, 126.

Authorities: General Report Public Works, Canada, 1867-1882; Annual Report of the Department of Railways and Canals, Dominion of Canada, 1883-1889; Department of Public Works, Dominion of Canada, 1896.

M. No. 2.—FIRST AND LAST TRIPS OF STEAMERS BELONGING TO THE DETROIT AND CLEVELAND STEAM NAVIGATION COMPANY, BETWEEN DETROIT AND CLEVELAND.

Year.	First trip.	Last trip.	Year.	First trip.	Last trip.	Year.	First trip.	Last trip.
1863	Mar. 28		1875	Apr. 12		1887	Mar. 28	Nov. 27
1864	Mar. 28		1876	Apr. 4		1888	Mar. 28	Dec. 2
1865	Mar. 28		1877	Apr. 10		1889	Mar. 21	Dec. 2
1866	Apr. 10		1878	Mar. 21	Dec. 14	1890	Mar. 1	Dec. 4
1867	Apr. 8		1879	Apr. 1	Dec. 9	1891	Mar. 12	Dec. 1
1868	Mar. 24		1880	Mar. 8	Dec. 2	1892	Mar. 27	Dec. 4
1869	Apr. 6		1881	Apr. 19	Dec. 12	1893	Mar. 29	Dec. 2
1870	Apr. 8		1882	Mar. 14	Dec. 6	1894	Mar. 19a	Dec. 5
1871	Mar. 21		1883	Apr. 7	Dec. 8	1895	Apr. 4	Dec. 5
1872	Apr. 3		1884	Apr. 2	Dec. 4	1896	Mar. 30	
1873	Apr. 8		1885	Mar. 17	Dec. 5			
1874	Mar. 23		1886	Mar. 25	Dec. 1			

a Could have gone to Cleveland on the 12th had steamer been ready.

Average date of first trip, March 25; average date of last trip, December 5; average number of days not running, 110.

Authority: Mr. D. Carter, general manager.

NOTE.—1878-1887. The closing of these seasons were generally on account of freezing up. 1888-1895. The closing trips of these years were not governed so much by the close of navigation.

All other departures were made as soon as could be on account of ice, except 1890, when a steamer could have run all winter so far as ice was concerned.

M. No. 3.—HUDSON CITY, N. Y.—HUDSON RIVER.

Year.	Opened.	Closed.	Year.	Opened.	Closed.	Year.	Opened.	Closed.
1817		Dec. 14	1836		Dec. 24	1857		
1818		Dec. 12	1837		Dec. 23	1858		Jan. 15
1819		Dec. 12	1838		Nov. 25	1858		Dec. 18
1820		Nov. 30	1839		Dec. 19	1859		Dec. 10
1821		Dec. 5	1840		Dec. 21	1860		Dec. 12
1822		Dec. 25	1841		Dec. 19	1871		Dec. 4
1823		Dec. 9	1842		Nov. 29	1862		Dec. 19
1824			1843		Dec. 30	1863		Dec. 9
1825		Jan. 5	1844		Dec. 13	1864		Dec. 18
1825		Dec. 12	1845		Dec. 4	1865		Dec. 19
1826		Dec. 20	1846		Dec. 14	1866		Dec. 15
1827		Dec. 18	1847		Dec. 27	1867		Dec. 9
1828		Dec. 25	1848		Dec. 30	1868		Dec. 10
1829			1849		Dec. 24	1869		Dec. 7
1830		Jan. 11	1850		Dec. 17	1870		
1830			1851		Dec. 11	1871		
1831		Jan. 12	1852			1872		
1831		Dec. 6	1853		Jan. 17	1873		
1832		Dec. 7	1853		Dec. 20	1874		
1833		Dec. 12	1854		Dec. 17	1875		
1834		Dec. 14	1855		Dec. 26	1876		
1835		Dec. 15	1856		Dec. 13			

Authority: Capt. A. W. Seaman.

M. No. 4.—MOOSE FORT, MOOSE RIVER, JAMES BAY.

[51° 16″ latitude north. 80° 56″ longitude west.]

Year.	Opened.	Closed.	Year.	Opened.	Closed.	Year.	Opened.	Closed.
1877		Dec. 7	1884			1891	May 2	Nov. 18
1878	Apr. 29	Nov. 2	1885			1892	May 17	Nov. 12
1879			1886			1893	May 13	Nov. 16
1880	May 9	Nov. 2	1887			1894	Apr. 30	Nov. 11
1881			1888			1895	May 1	Nov. 20
1882			1889	May 9	Nov. 14	1896		
1883			1890	May 24	Nov. 5			

Average date of opening, May 9; average date of closing, November 13; average number of days closed, 177.

Authority: Mr. Hugh. V. Payne, Meteorological Office, Toronto.

M. No. 5.—PORTAGE, WIS.

[43° 33′ latitude north. Altitude, 790 feet. 89° 25′ longitude west.]

Year.	Opened.	Closed.	Year.	Opened.	Closed.	Year.	Opened.	Closed.
1853	Mar. 1		1868	Mar. 16		1882	Feb. 14	
1854	Mar. 27		1869	Mar. 28		1883	Apr. 5	
1855	Mar. 3		1870	Apr. 3		1884	Mar. 28	
1856	Mar. 23		1871	Mar. 13		1885	Apr. 6	
1857	Apr. 1		1872	Apr. 10		1886	Apr. 5	
1858	Apr. 13		1873	Mar. 31		1887	Apr. 2	
1859	Apr. 11		1874	Mar. 30		1888	Apr 6	
1860	Mar. 10		1875	Apr. 6		1889	Mar. 20	
1861	Mar. 31		1876	Apr. 4		1890	Mar. 24	
1862	Apr. 3		1877	Feb. 22		1891	Apr. 4	
1863	Mar. 30			Mar. 29		1892	Mar. 27	
1864	Mar. 29		1878	Feb. 24		1893	Mar. 30	
1865	Mar. 20		1879	Mar. 26		1894	Mar. 5	
1866	Apr. 12		1880	Mar. 5		1895	Mar. 25	
1867	Apr. 11		1881	Apr. 15		1896	Mar. 25	

Authority: Portage Daily Register, March 26, 1896.

M. No. 6.—RIMOUSKI, PROVINCE OF QUEBEC.

[48° 28′ latitude north. 68° 31′ longitude west.]

Year.	Opened.	Closed.	Year.	Opened.	Closed.	Year.	Opened.	Closed.
1867	Mar. 15	Dec. 12	1877	Apr. 1	Dec. 5	1887		
1868	Mar. 20	Dec. 10	1878	Apr. 7	Nov. 28	1888		
1869	Mar. 19	Dec. 8	1879	Apr. 10	Dec. 1	1889		
1870	Mar. 18	Dec. 25	1880	Mar. 17	Dec. 19	1890		
1871	Apr. 5	Dec. 15	1881	Mar. 20	Dec. 25	1891		
1872	Apr. 1	Dec. 12	1882	Mar. 22	Dec. 15	1892		
1873	Apr. 3	Dec. 10	1883	Mar. 12	Dec. 15	1893		
1874	Mar. 24	Dec. 1	1884	Mar. 15	Nov. 9	1894		
1875	Mar. 20	Nov. 26	1885	May 11	Nov. 9	1895		
1876	Mar. 30	Dec. 1	1886	May 1		1896		

Authorities: General Report Public Works, Canada, 1867–1882; Annual Report of the Department of Railways and Canals, Dominion of Canada, 1883-1889; Mr. R. Steckel, C. E., engineer Technical Branch, Dominion of Public Works, Canada.

M. No. 7.—ST. CLOUD, MINN.

[45° 32′ latitude north. Altitude, 962 feet. 94° 06′ longitude west.]

Year.	Opened.	Closed.	Year.	Opened.	Closed.	Year.	Opened.	Closed.
1876			1883			1890	Apr. 14	Dec. 2
1877			1884			1891	Apr. 13	Nov. 14
1878			1885			1892	Apr. 6	Nov. 21
1879			1886			1893	Apr. 15	Nov. 19
1880			1887			1894	Apr. 5	Nov. 16
1881			1888	Apr. 16		1895	Apr. 1	Nov. 20
1882			1889			1896	Apr. 14	

Authority: Mr. A. Hennemann.

M. No. 8.—WILMINGTON, ILL.

Year.	Opened.	Closed.	Year.	Opened.	Closed.	Year.	Opened.	Closed.
1862	Jan. 28		1874			1886	Feb. 14	Dec. 3
1863			1875			1887	Feb. 8	Nov. 27
1864	Jan. 27		1876			1888		
1865			1877			1889		Nov. 29
1866	Mar. 2		1878			1890		
1867	Feb. 13		1879			1891		Nov. 29
1868	Mar. 1		1880			1892		
1869			1881	Feb. 24		1893		Nov. 24
1870			1882			1894		Dec. 28
1871			1883	Feb. 16	Nov. 17	1895		Dec. 3
1872			1884	Mar. 19	Nov. 23	1896	Feb. 21	
1873			1885	Mar. 28	Dec. 20			

M. No. 9.—MISCELLANEOUS NOTES.

Location.	Latitude north.	Longitude west.	Altitude.	Estimated average dates.		Average days closed.	Authority for estimated average.
				Closed.	Opened.		
	° ′	° ′	*Feet.*				
Norway House	53 40	98 00	708	Nov. 26	June 1	187	Mr. C. C. Chipman.
Oxford Lake	55 02	95 16	.....	Nov. 1	June 4	215	Do.
Battleford, Sask	52 45	108 30	.....	Nov. 29	Apr. 30	180	Mr. J. G. Oliver.
Fort Churchill	58 52	95 00	.....	Nov. 15	June 15	212	Mr. J. B. Tyrell.
Moose Fort, James Bay	51 16	80 56	.....	Nov. 13	May 9	177	Mr. Hugh V. Payne.
Lake Nipissing, Ont	46 16	79 45	642	Nov. 29	May 3	155	Mr. H. C. Varin.
Lake St. John, Ont	48 25	71 35	293	Dec. 1	May 10	160	Mr. G. F. Baillairge.
Breckenridge, Minn	46 10	96 32	958	Nov. 15	Apr. 15	151	Mr. E. Mattson.
Grand Forks, N. Dak	47 55	97 01	787	Nov. 8	Apr. 15	158	Mr. A. O. Powell, assistant United States engineer.
St. Cloud, Minn	45 32	94 06	962	Nov. 20	Apr. 9	140	Mr. A. Hennemann.
Granite Falls, Minn	44 50	95 35	870	Nov. 10	Apr. 1	142	Mr. George Sein.
McGregor, Iowa	43 01	91 10	604	Nov. 24	Mar. 30	126	Monthly Weather Review.
Lafayette, Ind	40 25	86 53	505	Dec. 23	Jan. 19	27	Prof. H. A. Huston.
Ticonderoga, N. Y	43 51	73 23	95	Dec. 9	Apr. 12	124	Mr. F. A. Baldwin.
Allentown, Pa	40 38	75 33	221	Dec. 31	Feb. 14	45	Mr. A. L. Richenbad.
Lynchburg, Va	37 12	79 06	523	Dec. 8	Jan. 6	29	Mr. L. F. Lucado.
Wilmington, Ill	41 21	88 07	.....	Dec. 1	Mar. 1	90	Wilmington Advocate.

A No. 1.—COLUMBIA, PA.—SUSQUEHANNA RIVER.

Year.	Opened.	Closed.	Year.	Opened.	Closed.	Year.	Opened.	Closed.
1872	Mar. 25	Dec. 1	1881	Feb. 12	.....	1890	Open.	Dec. 10
1873	Mar. 19	Dec. 5	1882	Feb. 2	Dec. 16	1891	Jan. 5	Open.
1874	.....	Open.	1883	Feb. 18	Dec. 15	1892	Open.	Nov. 30
1875	Mar. 18	Dec. 16	1884	Feb. 7	Dec. 15	1893	Feb. 10	Open.
1876	.....	Dec. 2	1885	Apr. 3	.....	1894	Open.	Dec. 8
1877	Feb. 3	.....	1886	Feb. 13	Dec. 4	1895	Jan. 11	Feb. 11
1878	Feb. 11	.....	1887	Jan. 26	Dec. 20		Mar. 4	Dec. 15
1879	Mar. 10	Dec. 22	1888	Feb. 22	Dec. 14	1896	Mar. 1	Dec. 2
1880	.....	Nov. 25	1889	Mar. 5	Open.			

Average date of opening, February 16; average date of closing, December 21; average number of days closed, 57.

Authority: Mr. E. F. Smith, superintendent and engineer, canal division.

A No. 2.—LOWELL, MASS.

Year.	Opened.	Closed.	Year.	Opened.	Closed.	Year.	Opened.	Closed.
1847	.....	.....	1865	Mar. 17	Dec. 8	1883	Apr. 9	Dec. 15
1848	.....	Jan. 6		.....	Dec. 14	1884	Mar. 23	Dec. 18
1848	Mar. 21	Dec. 23	1866	Feb. 25	Mar. 7	1885	Jan. 12	Jan. 17
1849	Mar. 21	Dec. 8		.....	Dec. 14		Apr. 1	Dec. 5
1850	Feb. 21	Dec. 13	1867	Mar. 23	Nov. 19		Dec. 10	Dec. 20
1851	Feb. 25	Dec. 2		.....	Dec. 4	1886	Jan. 4	Dec. 3
1852	Jan. 15	Dec. 21	1868	Mar. 18	Dec. 6	1887	Mar. 20	Dec. 22
1853	Feb. 7	Feb. 11	1869	Mar. 29	Dec. 8	1888	Mar. 29	Dec. 13
	Feb. 24	Mar. 16	1869	Dec. 30	.....	1888	Dec. 18	.....
	.....	Dec. 5	1870	.....	Feb. 3	1889	.....	Jan. 30
	Dec. 18	Dec. 20	1870	Feb. 19	Dec. 16	1889	Mar. 4	.....
1854	Mar. 13	Mar. 28	1871	Mar. 5	Nov. 28	1890	.....	Jan. 9
	.....	Dec. 2	1872	Apr. 5	Nov. 30	1890	Feb. 9	Feb. 20
1855	Mar. 18	Dec. 12		.....	Dec. 9		Feb. 27	Dec. 10
1856	Apr. 8	Dec. 1	1873	Apr. 3	Nov. 21	1891	Mar. 11	Dec. 17
1857	Feb. 19	Mar. 2		Dec. 18	Dec. 22	1891	Dec. 23	.....
	.....	Dec. 26		Jan. 8	Jan. 15	1892	.....	Jan. 24
1858	Jan. 28	Feb. 11	1874	Mar. 4	Mar. 12	1892	Mar. 23	Dec. 20
	Mar. 19	Nov. 30		Mar. 20	Dec. 12	1893	Mar. 29	Dec. 4
1859	Mar. 16	Dec. 8	1875	Nov. 28	Nov. 25	1894	Mar. 7	Nov. 29
1860	Mar. 2	Dec. 14			Nov. 30	1895	Mar. 27	Dec. 6
1861	Mar. 3	Dec. 3	1876	Mar. 22	Dec. 2	1896	Mar. 1	.....
	.....	Dec. 20	1877	Mar. 27	.....		Mar. 19	Mar. 13
1862	Apr. 3	Dec. 6	1878	.....	Jan. 1			
	Dec. 17	Dec. 19	1878	Mar. 4	Dec. 20			
1863	Jan. 17	Jan. 21	1879	Mar. 30	Dec. 18			
	.....	Feb. 3	1880	Feb. 27	Nov. 22			
	Mar. 26	Dec. 7	1881	Mar. 15	.....			
	Dec. 14	Dec. 21	1882	.....	Jan. 3			
1864	Mar. 7	Dec. 10	1882	Mar. 6	Nov. 29			

Authority: Mr. Arthur T. Safford, assistant engineer of props, locks, and canals, Merrimac River.

A No. 3.—PORT CLINTON, PA.—SCHUYLKILL RIVER.

Year.	Opened.	Closed.	Year.	Opened.	Closed.	Year.	Opened.	Closed.
1853	.....	Dec. 23	1868	.....	Dec. 9	1882	Feb. 13	Dec. 16
1854	.....	.....	1869	Mar. 10	Dec. 10	1883	Feb. 15	Dec. 20
1855	.....	.....	1870	.....	.....	1884	Feb. 8	Dec. 1
1856	.....	.....	1871	.....	.....	1885	Feb. 17	.....
1857	Feb. 9	Nov. 21	1872	Mar. 23	Nov. 18	1886	Feb. 13	Dec. 4
1858	.....	.....	1873	Mar. 15	Open.	1887	Jan. 29	Dec. 20
1859	.....	.....	1874	Open.	.....	1888	Mar. 2	Dec. 14
1860	.....	.....	1875	Mar. 18	Dec. 18	1889	Mar. 4	Open.
1861	.....	Open.	1876	.....	Dec. 2	1890	Open.	Dec. 2
1862	.....	Dec. 5	1877	Feb. 2	Open.	1891	Jan. 5	Open.
1863	.....	Dec. 23	1878	Open.	Dec. 21	1892	Open.	Dec. 10
1864	.....	Dec. 8	1879	Feb. 12	Dec. 21	1893	Feb. 26	Open.
1865	.....	Dec. 16	1880	.....	Nov. 22	1894	Open.	Dec. 8
1866	.....	Dec. 13			Dec. 8	1895	Mar. 4	Dec. 5
1867	.....	Dec. 9	1881	Feb. 10	.....	1896	Mar. 10	.....

Authority: Mr. E. F. Smith, superintendent and engineer, canal division.

A No. 4.—SPRINGFIELD, MASS.

Year.	Opened.	Closed.	Year.	Opened.	Closed.	Year.	Opened.	Closed.
1864	Mar. 8	Dec. 20	1874	Feb. 23	Mar 13	1885	Mar. 30	Dec. 26
1865	Mar. 16	Dec. 16		Mar. 16	Nov. 26	1886	Feb. 16	Dec. 8
1866	Feb. 25	Mar. 10		Dec. 3	Dec. 11	1887	Mar. 18	Dec. 4
	Mar. 13	Dec. 15	1875	Apr. 5	Nov. 28	1888	.....	.....
1867	Mar. 1	Dec. 20	1876	Jan. 22	Feb. 3	1889	.....	.....
1868	Mar. 15	Dec. 12		Mar. 8	Dec. 1	1890	.....	.....
1869	Apr. 1	.....	1877	Mar. 9	Dec. 26	1891	.....	.....
	Dec. 27	Dec. 7	1878	Jan. 23	Dec. 22	1892	.....	.....
1870	Jan. 10	.....	1879	Mar. 23	Dec. 21	1893	.....	.....
	Feb. 20	Dec. 17	1880	Jan. 29	Dec. 12	1894	.....	.....
1871	Mar. 3	Nov. 29	1881	Mar. 9	Dec. 11	1895	.....	.....
1872	Apr. 3	Dec. 10	1882	Mar. 2	Nov. 30	1896	.....	.....
1873	Apr. 2	Nov. 27	1883	Mar. 28	Dec. 3			
1874	Jan. 6	Jan. 25	1884	Mar. 18	Dec. 19			

Authority: Mr. Hervey J. Deming.

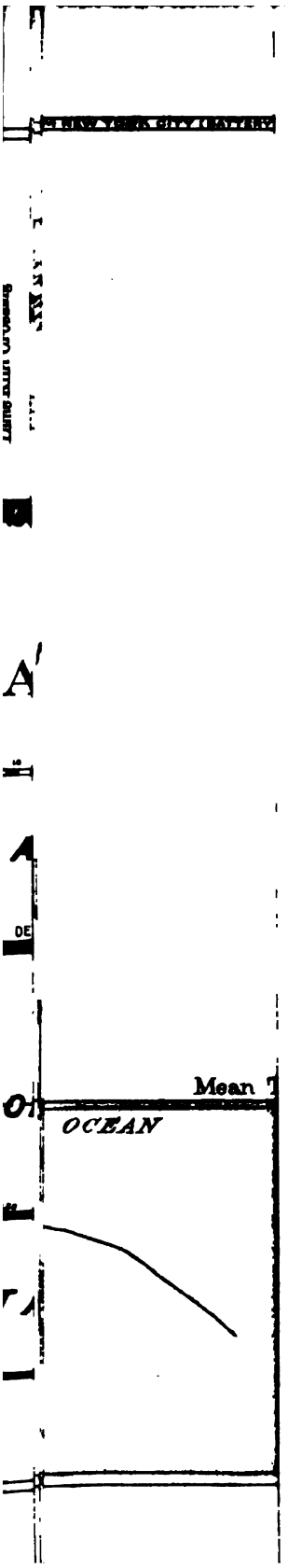
A No. 5.—WASHINGTON PARK, CHICAGO.

Year.	Opened.	Closed.	Year.	Opened.	Closed.	Year.	Opened.	Closed.
1889	Feb. 28	Jan. 2	1894	Mar. 1	Jan. 2	1896	Dec. 6	Dec. 3
1890	Feb. 25	Jan. 1	1894	.....	Dec. 29	1897	.....	.....
1891	Mar. 5	Jan. 4	1895	Feb. 23	.....			
1892	Feb. 24	Jan. 3	1895	.....	Dec. 3			
1892	.....	Dec. 18	1896	Feb. 28	.....			
1893	Feb. 27	.....						

Average date of opening, February 27; average date of closing, December 27; average number of days closed, 62.

Authority: Mr. C. W. Nugent.

O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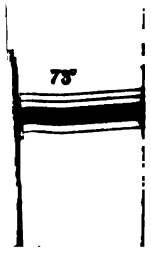
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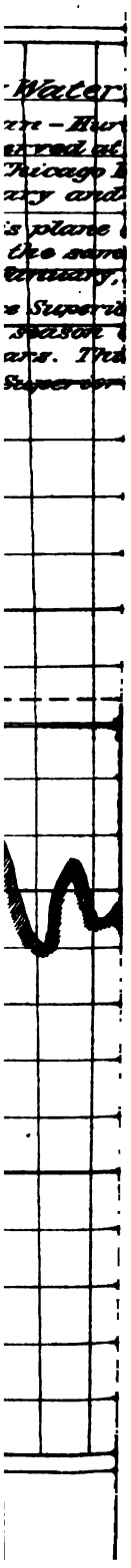

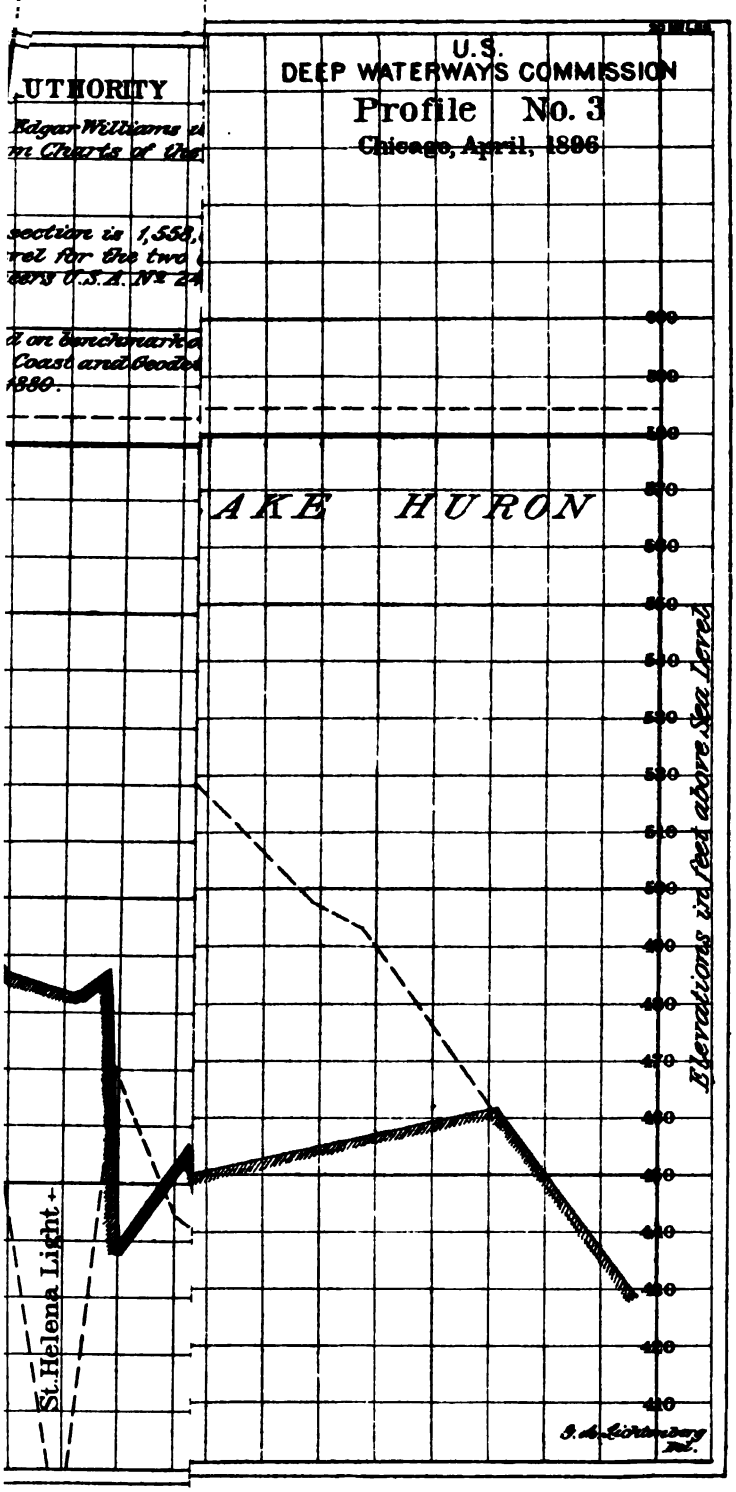
U.S.
DEEP WATERWAYS COMMISSION
Profile No. 3
Chicago, April, 1896
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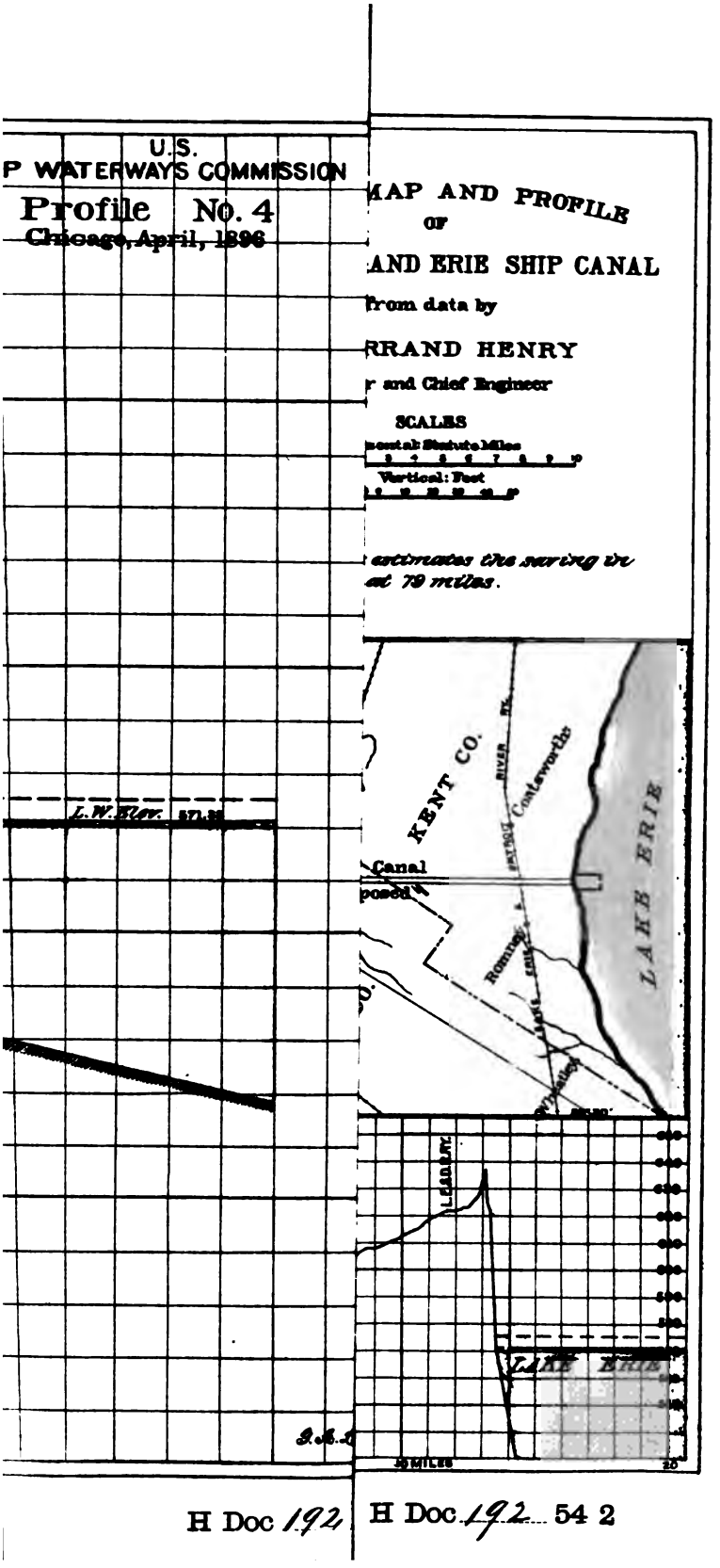
1880.
AKE HURON
Elevations in feet above Sea Level
St. Helena Light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P WATERWAYS COMMISSION
Profile No. 4
Chicago, April, 1896
AP AND PROFILE
OF
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SCALES
ontal: Statute Miles
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L.W. Elev.
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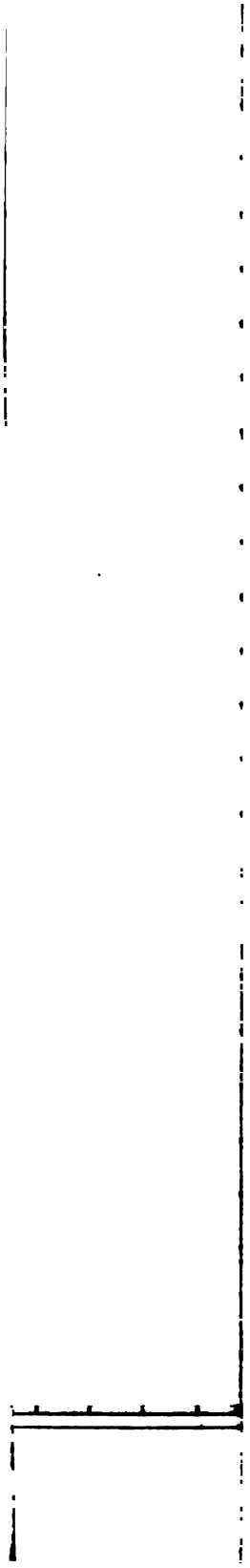

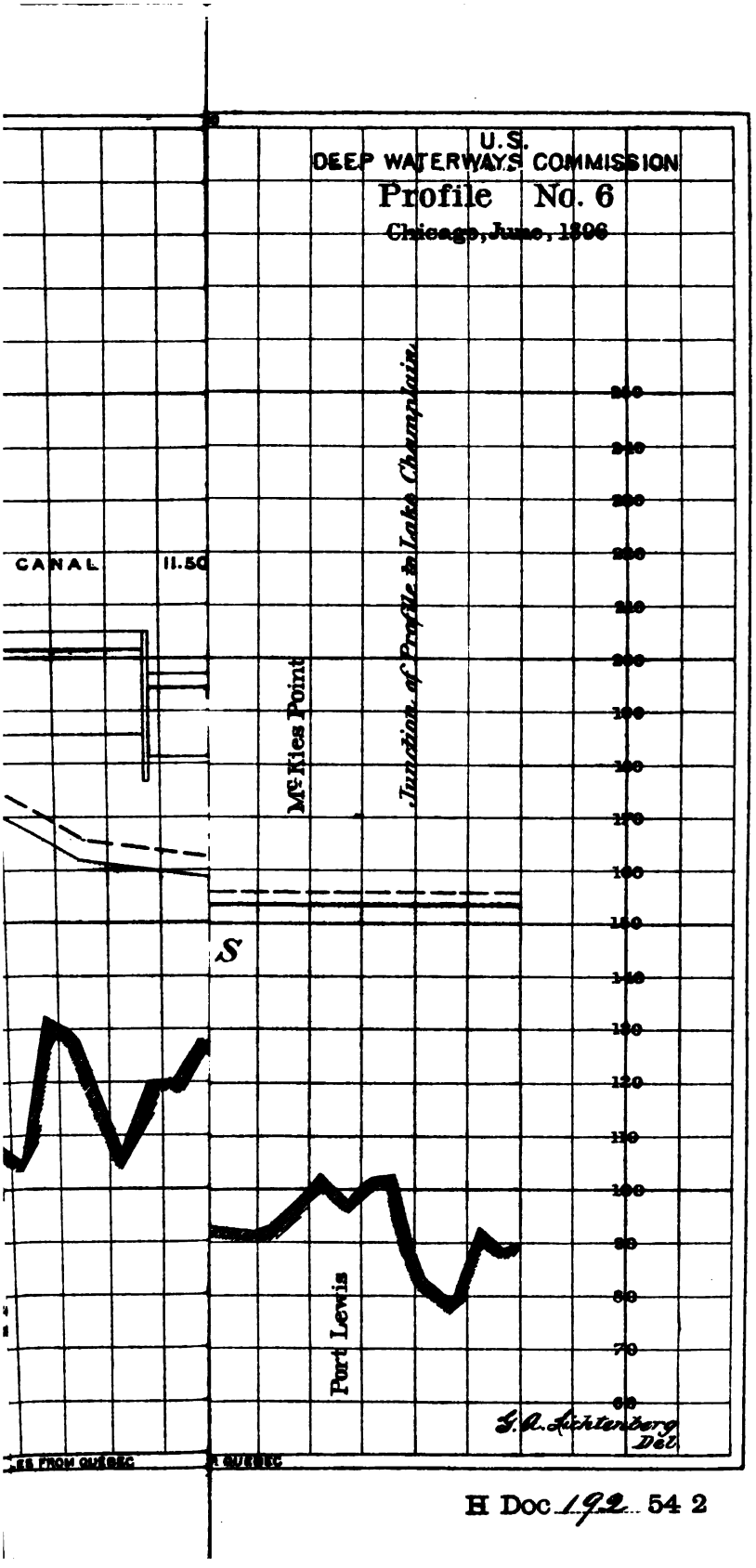
U.S.
DEEP WATERWAYS COMMISSION
Profile No. 6
Chicago, June, 1906
Junction of Profile in Lake Champlain.
McKies Point
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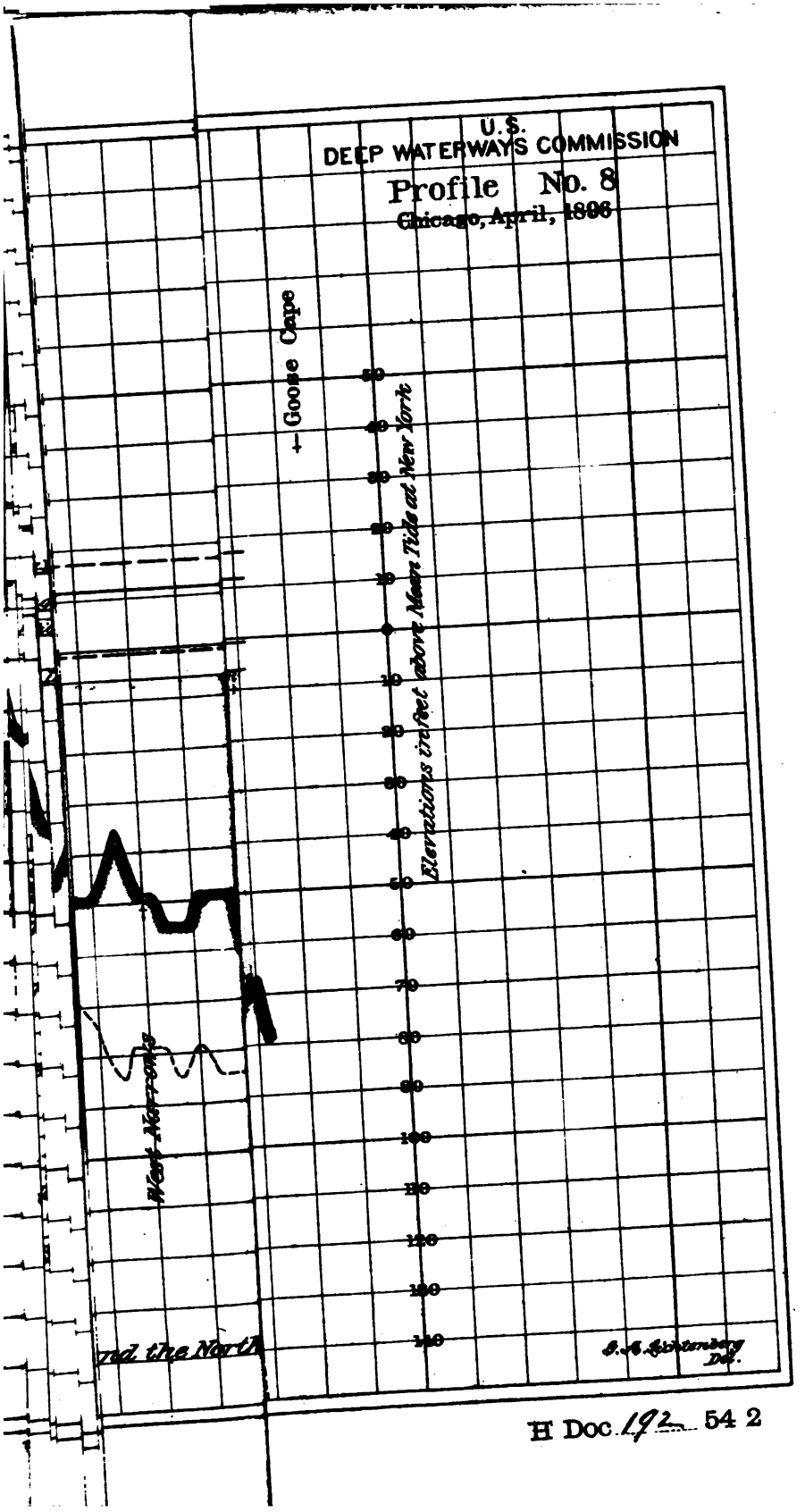
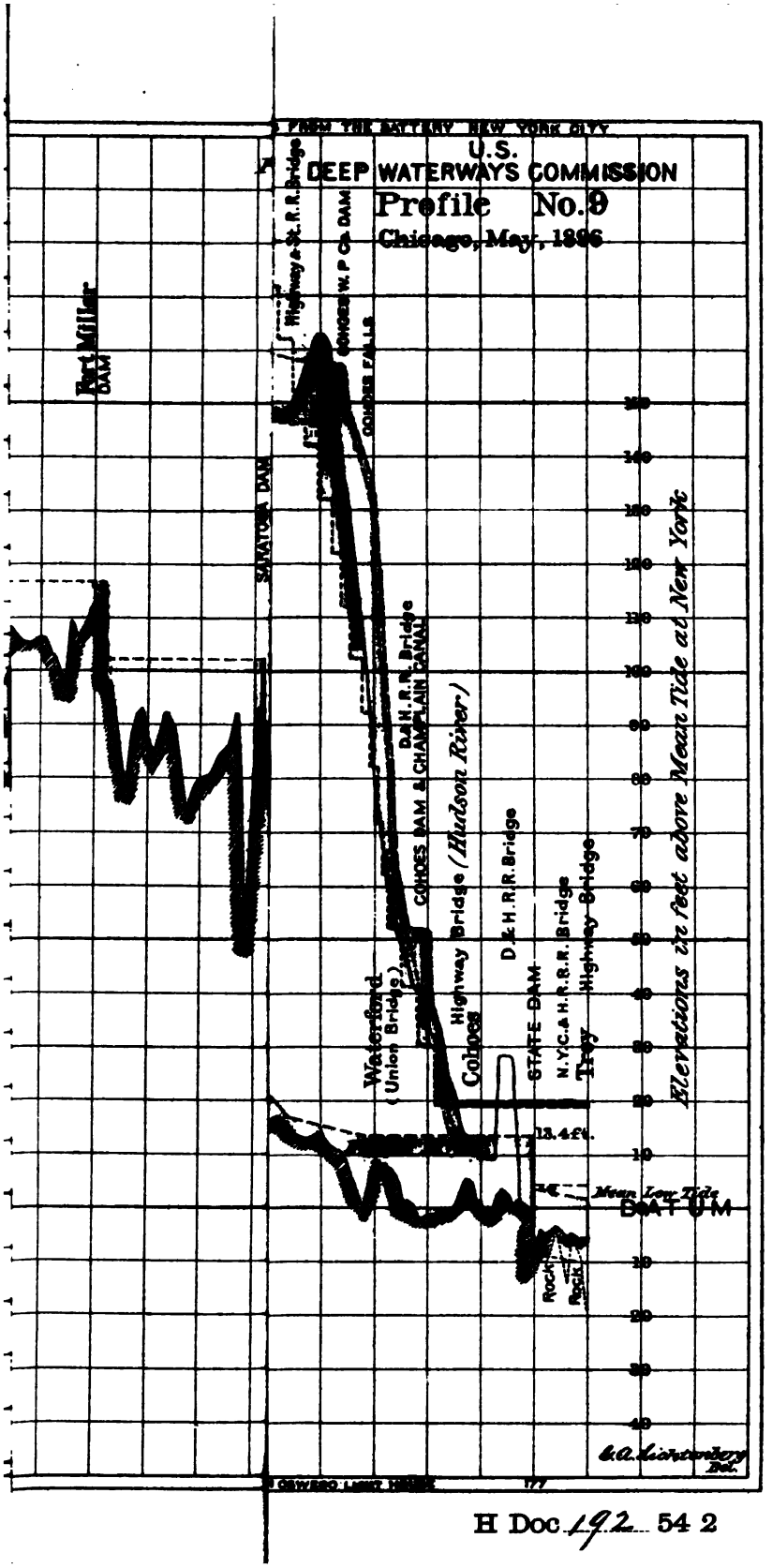
S
L. A. Lichtenberg
Del.

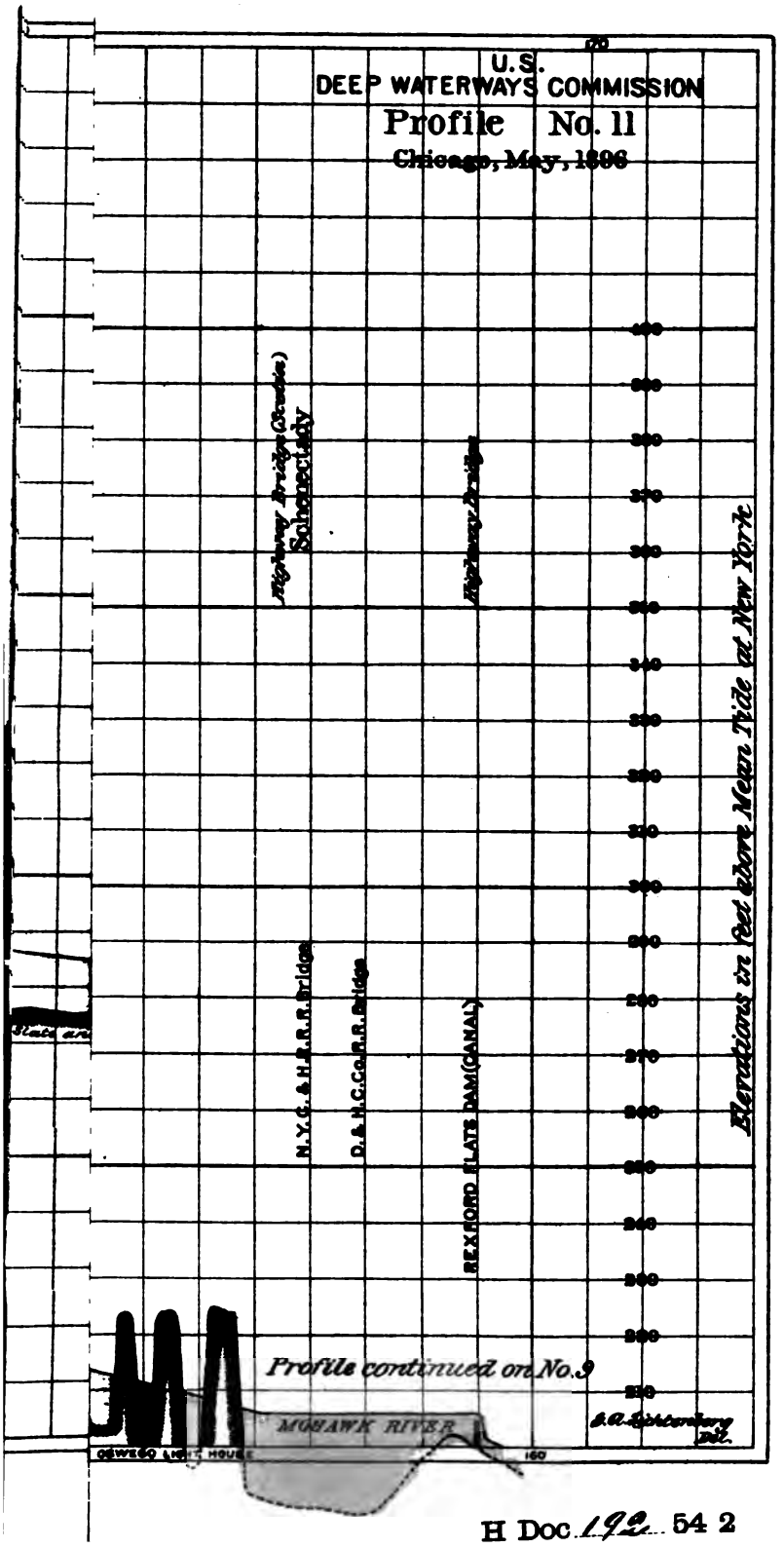
H Doc. 192 54 2

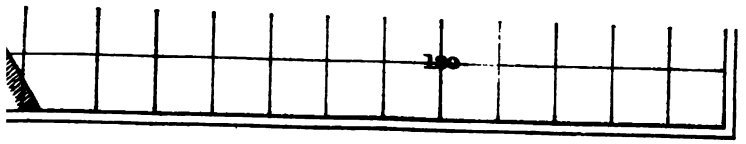

U.S.
DEEP WATERWAYS COMMISSION
Profile No. 8
Chicago, April, 1906
Goose Cape
Elevations in feet above Mean Tide at New York
West Narrows
and the North

H Doc. 192 54 2


FROM THE BATTERY NEW YORK CITY
U.S.
DEEP WATERWAYS COMMISSION
Profile No. 9
Chicago, May, 1896
Fort Miller DAM
Highway & St. R.R. Bridge
CONCRETE W. P. Co. DAM
CONCRETE FALLS
SARATOGA DAM
D. & H. R.R. Bridge
CHAMPLAIN CANAL
COHOES DAM
Highway Bridge (Hudson River)
Waterford (Union Bridge)
Cohoes
D. & H. R.R. Bridge
STATE DAM
N.Y.C. & H.R.R.R. Bridge
Troy
Highway Bridge
13.4 ft.
Mean Low Tide
DATUM
Rock
Rock
Elevations in feet above Mean Tide at New York
U.S. Lighthouse Est.

H Doc 192 54 2


U.S.
DEEP WATERWAYS COMMISSION
Profile No. 11
Chicago, May, 1896
Highway Bridge (Swedie)
Schenectady
Highway Bridge
N.Y.C. & H.R.R.R. Bridge
D. & H.C.Co.R.R. Bridge
REXFORD FLATS DAM (CANAL)
Elevations in feet above Mean Tide at New York
Profile continued on No. 9
MOHAWK RIVER
OSWEGO LIGHT HOUSE
160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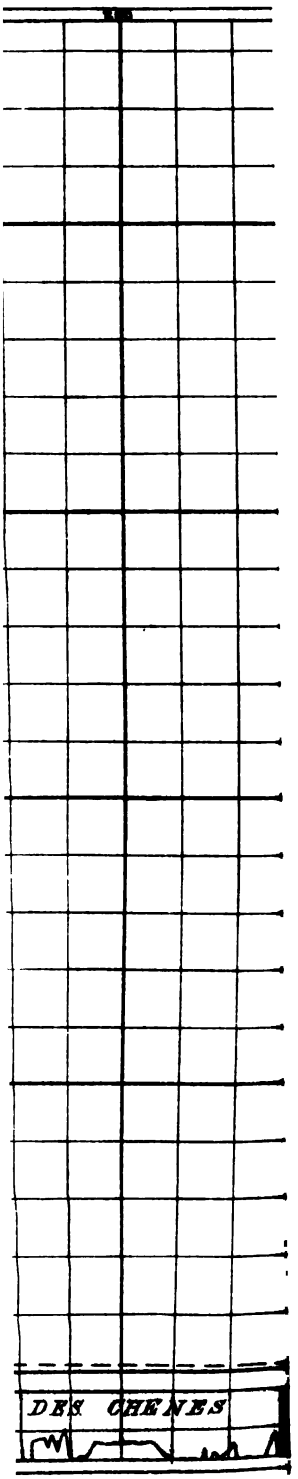
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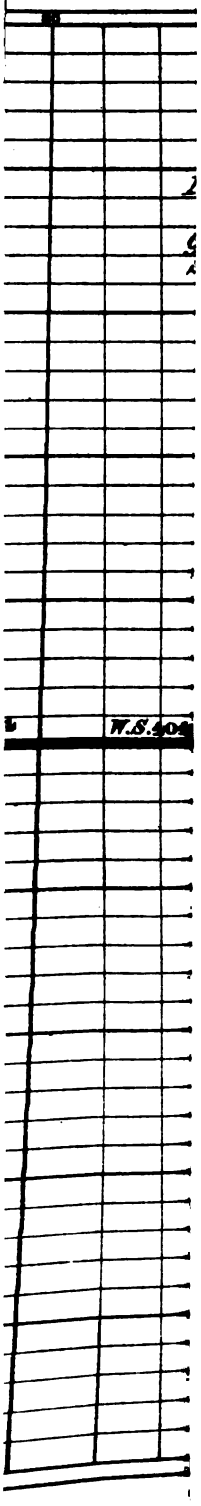

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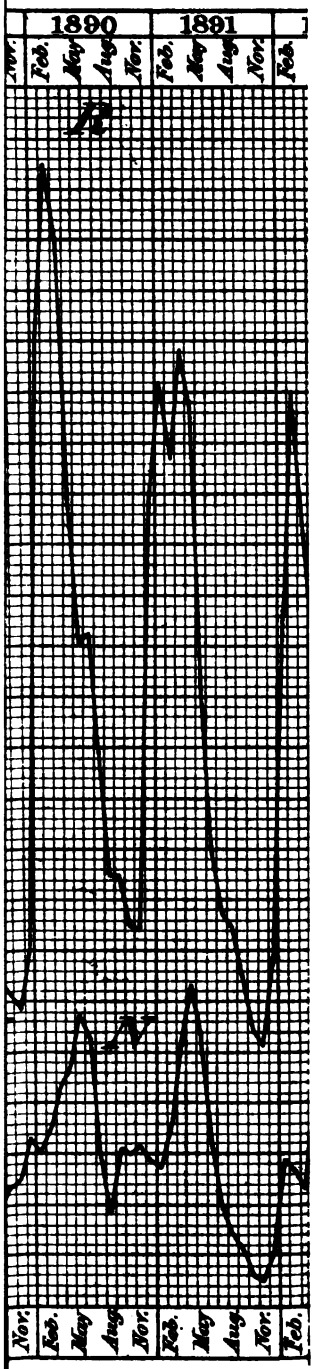
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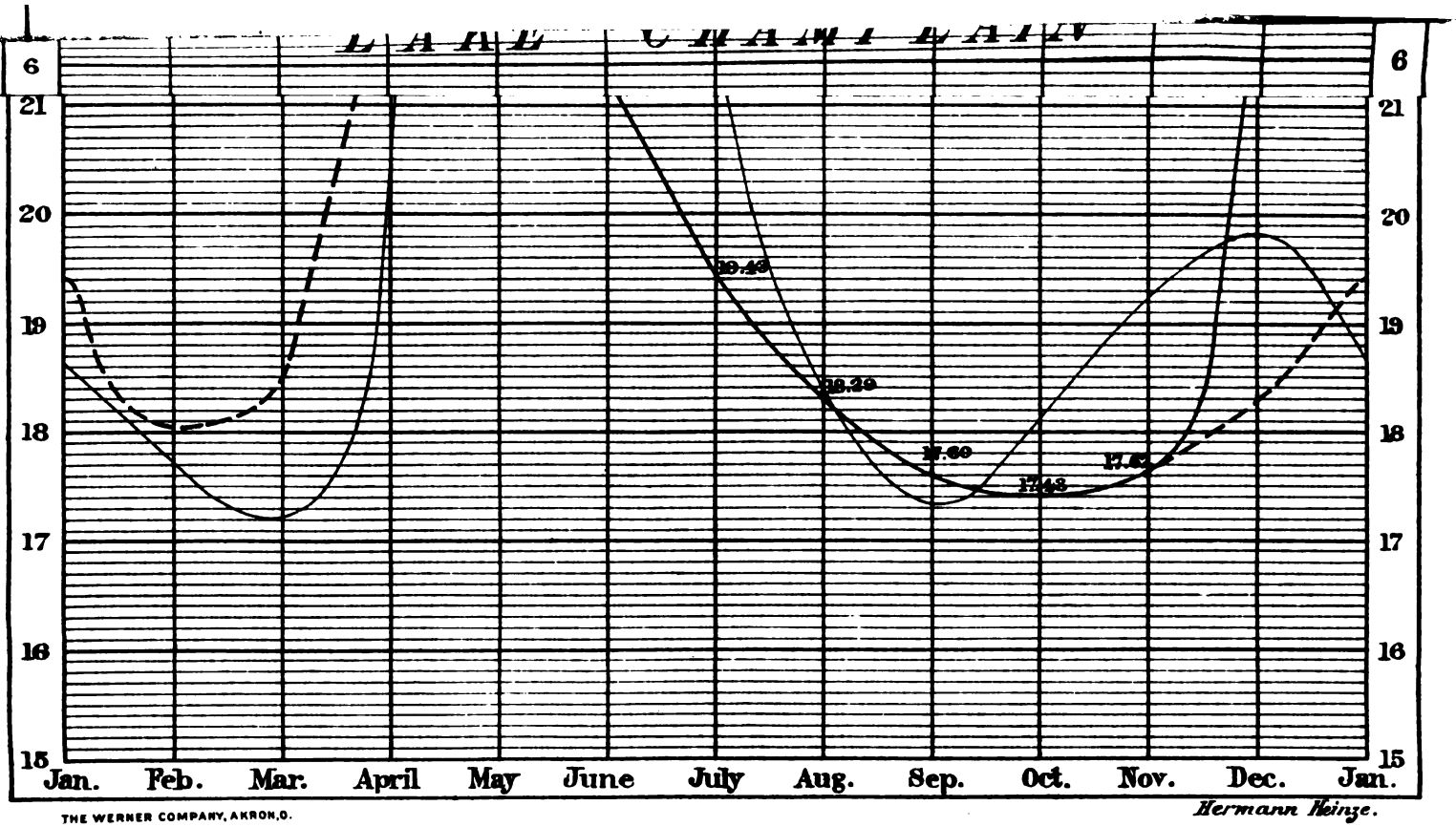

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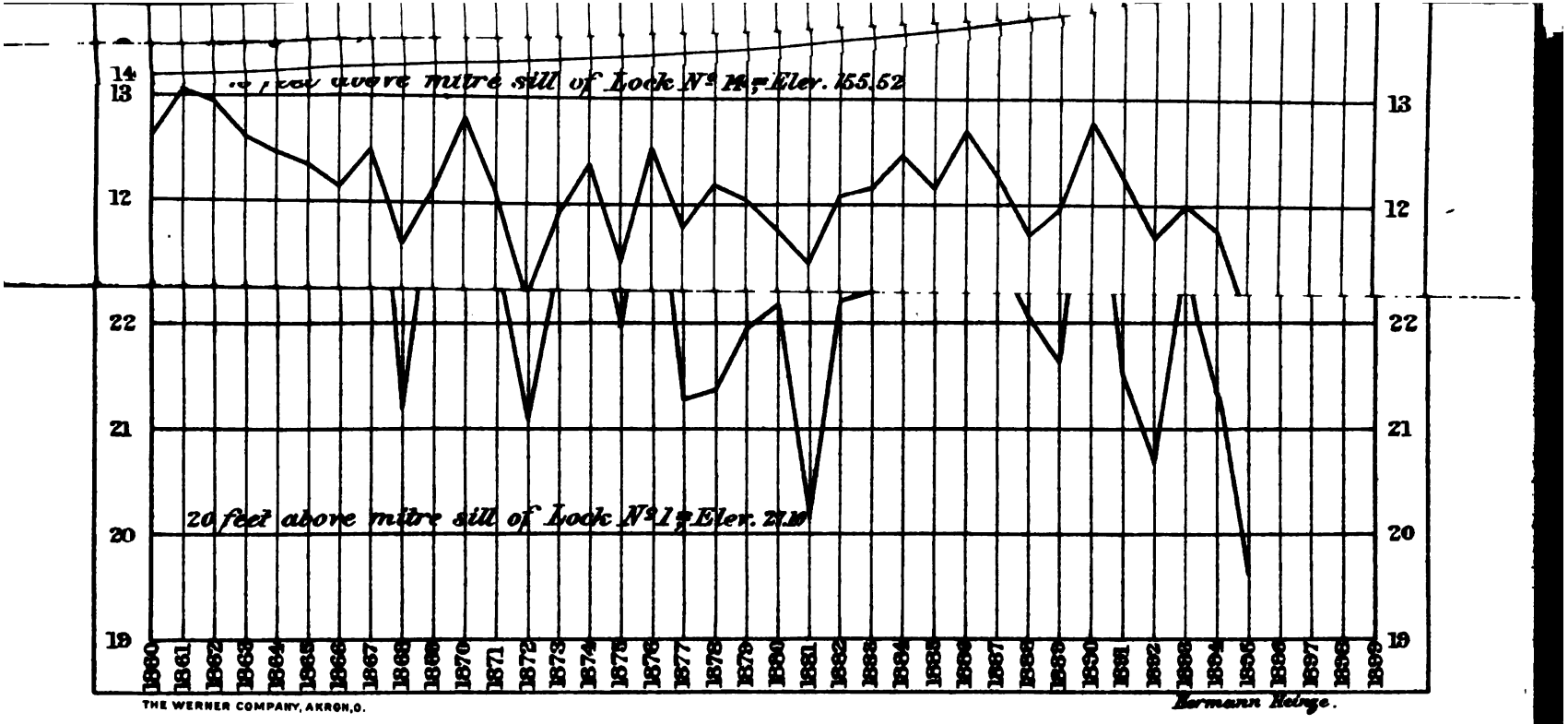
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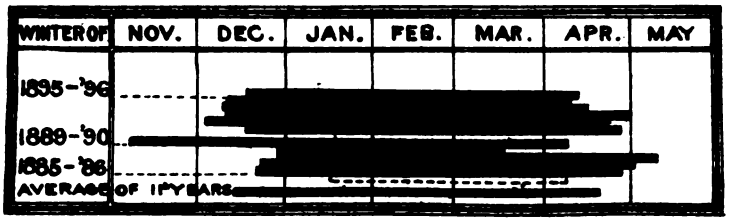
GRAND MARAIS LIGHT HOUSE, MINN.



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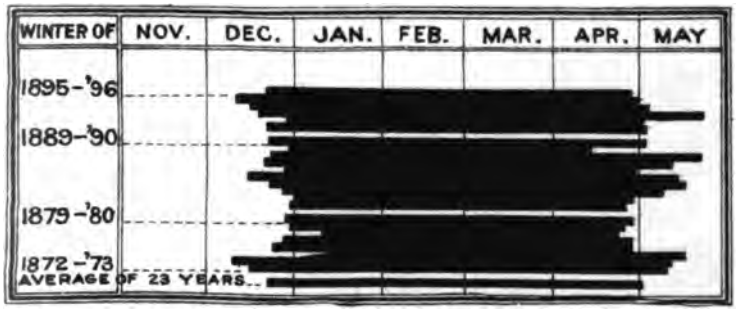
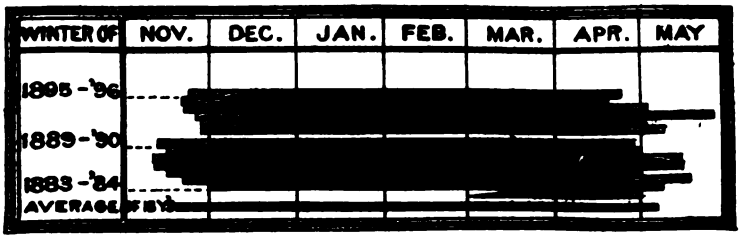
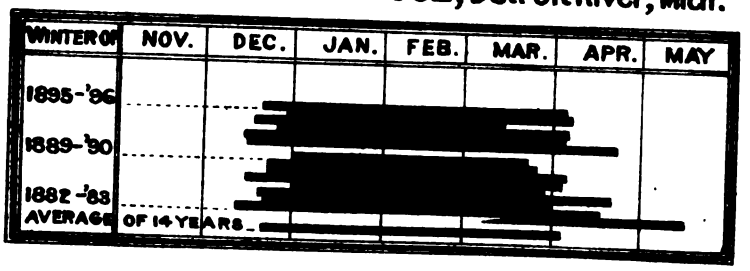


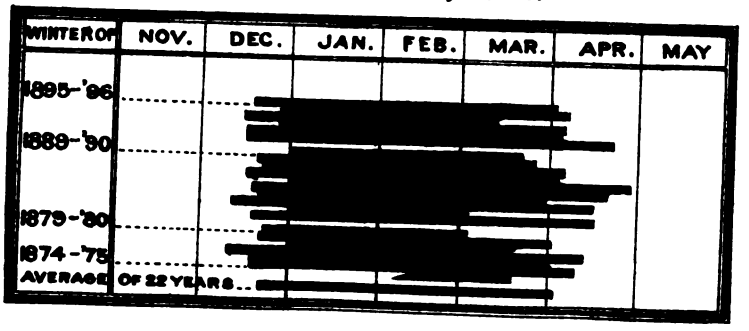
PASSAGE ISLAND L.H., Lake Superior, WIS.



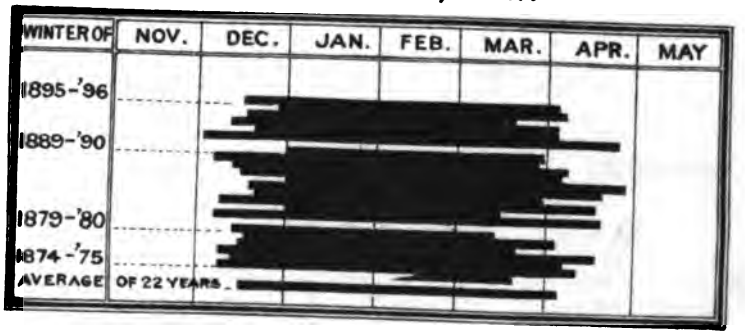
BELLE ISLE LIGHT HOUSE, Detroit River, Mich.



WINDMILL POINT LIGHT HOUSE, Lake St. Clair, Mich.



ST. CLAIR FLATS LIGHT HOUSE, Lake St. Clair, Mich.



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